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Marine Engine Governors.

By JASPER E. COOPER.

It is unnecessary to point out the very great importance, both to the ship-owner and engineer, of having a thoroughly good and efficient governor fitted to marine engines. An engine-builder would never think of constructing a land engine for any purpose where the load might vary without fitting a governor—indeed, land engines without them are exceedingly uncommon—yet we find marine engines of all sorts and sizes without any trace of a governor; and this in spite of the fact that the marine engine is liable to have the whole load suddenly removed at any time. This appears rather remarkable at first sight, but the explanation is not far to seek. By far the greater number of superintendent engineers, who are responsible for the fitting of such things, are men who have been to sea with some of the older forms of governors. Many of these governors are of such a delicate nature that they are constantly giving trouble, and in the end are disconnected and left to rust. Consequently, the impression on the minds of these gentlemen is that marine engine governors are a failure, and it is difficult to make them believe that great improvements have been made since their sea-going days. The consequence is that the governor is omitted from the specification and the safety of the ship made a matter of chance, for it must be remembered that a heavy race may possibly disable the engines. The question might be raised here, "What is racing, and what evils are due to it?" When an engine suddenly attains a speed of double the number of revolutions per minute at which it is intended to run, and is as suddenly brought up to its normal rate, it may be said to be racing (although very much worse racing than this is common enough), and the whole strain of the sudden check to the engine, caused by the extra resistance offered by the water to the propeller as it dips, after having been lifted partially out of the water, must necessarily be transmitted through the whole length of shafting and coupling-bolts from the crank-shaft to the propeller-shaft. The strain thrown upon the crank-shaft will vary with the circumstances, and if the valves have a good lead there should not be much strain due to the momentum of the pistons and rods, and this will be further reduced if working expansively by the link—as is usually the case in heavy weather—for then both lead and cushioning will be thereby increased; but it must be remembered that if the valves are set to suit a speed of piston of, say, 400 ft. per minute, there will never be sufficient lead or compression to check a speed of 1,000 ft. per minute, or upwards; so that the piston and rods come down heavily on the shaft, which accounts for the vibration of the whole engine. This vibration will be felt all the more by the throttle-valve being closed, as there will then be less

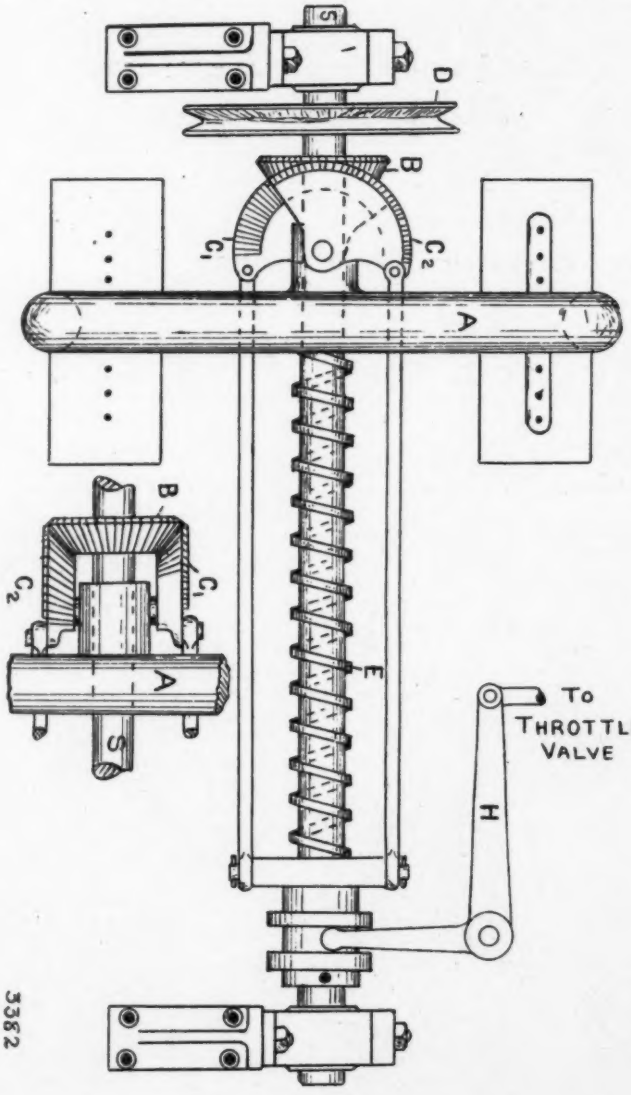


FIG. 1.—SILVER'S MARINE ENGINE GOVERNOR.

pressure in the cylinders, and, consequently, the lead and compression will be less effective. Of course, if the governor is quick enough to check the racing before the propeller is again immersed, the twisting strain to the shafting will be avoided, or at least greatly reduced. There is also a severe straining to the pumps, pump-rods, and links, caused by racing; the pumps being unable to deliver the water quick enough, and the bucket-valves, coming down heavily on the surface of the water, put extra weight on the rods and other gear, as well as destroying the valves; the feed-pumps being only partially filled with water, and the rams coming suddenly in contact with it, give a shock to the barrels of the pumps, and also to the pump cross-head, etc., which is not the case when running at a reasonable rate. A continuance of this vibration loosens the foundation plate of the engine; in fact, it would be difficult to say where the evil of racing ends, and it is only necessary for the shipowner to know a small portion of it in order to see the advantage of investing in a thoroughly efficient governor.

There are probably more ships fitted with some one of the older forms of governors than there are ships without governors, but very few are ever used, either because they never were efficient, or because they have been neglected and allowed to get out of order. For this reason we propose giving a brief description of some of the more important of the old governors in addition to the more recent ones.

Commencing at the beginning, we find the engines of the "Comet," built in 1811, fitted with the ordinary centrifugal ball governor; forty-five years later W. E. Newton patented an improvement in these governors, and in the following year Taylor introduced a governor on an entirely new principle. A cylinder was placed in near proximity to the propeller, and connected at the bottom to the sea; a float in this cylinder was connected with the throttle-valve by means of a rope or chain, with a balance-weight hanging at the further end. When the propeller was deeply immersed, the sea would fill the cylinder and keep the float at the top and the throttle-valve open, but as soon as the head of water decreased the float would fall until, the propeller being out of water, the throttle would be closed. The theory of this governor is sound enough, but it is not exactly a convenient one for practical use. Consequently Silver's governor, invented in the same year (1857) by Thos. Silver, gave greater satisfaction to the marine engineers of that day.

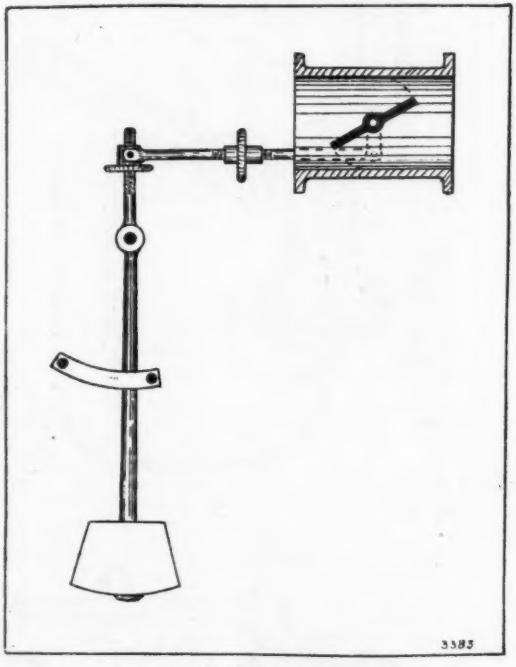


FIG. 2.—PINKER'S MARINE ENGINE GOVERNOR.

Silver's. This governor is shown in

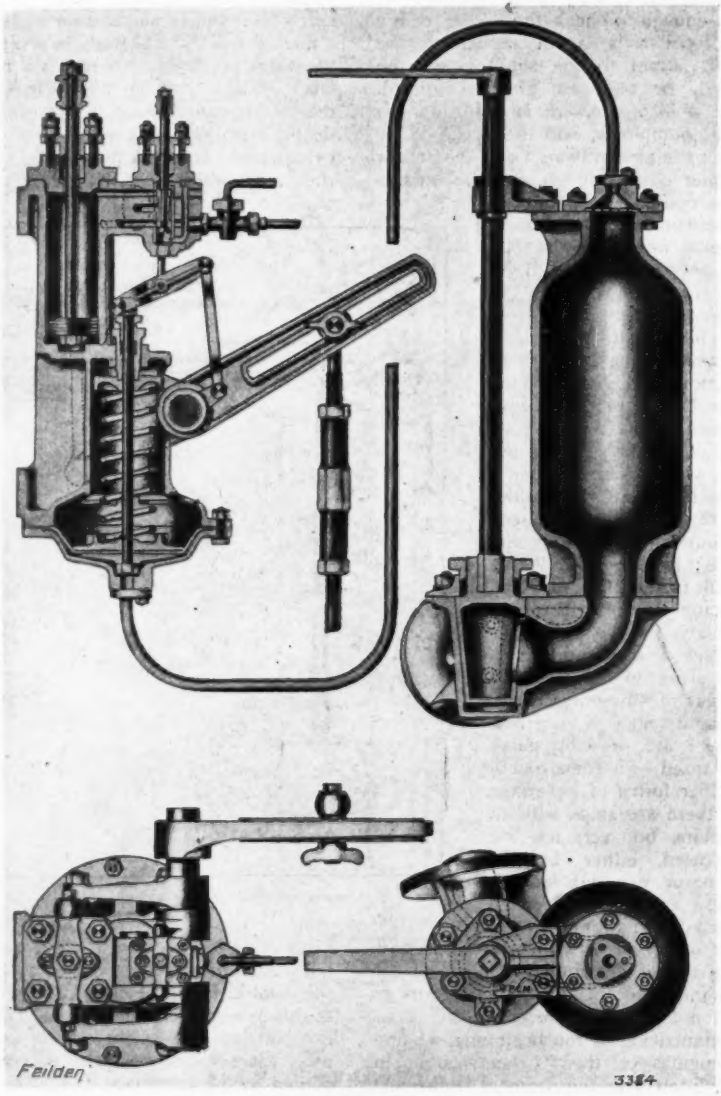


FIG. 3.—DUNLOP'S MARINE ENGINE GOVERNOR.

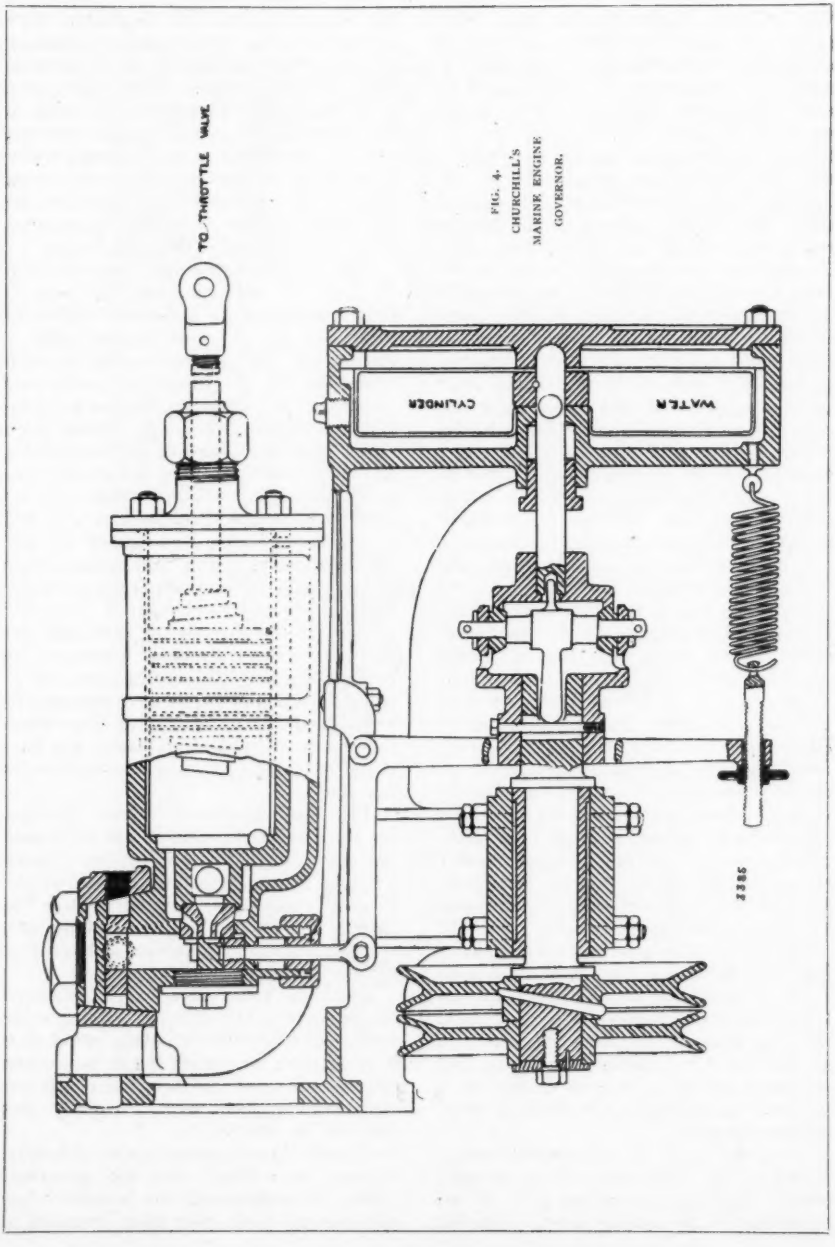


FIG. 4.
CHURCHILL'S
MARINE ENGINE
GOVERNOR.

Fig. 1. *A* is a large flywheel fitted with vanes (to absorb a certain amount of energy) and free to revolve on the shaft *S*, which is supported by brackets bolted to any convenient bulkhead. The bevel wheel *B* is keyed to the shaft, and the toothed quadrants *C*1 and *C*2 gear with it and are free to turn about pins on the extended boss of the flywheel. A rope is taken from some convenient position on the propeller-shaft and drives the pulley *D*, thus revolving the bevel wheel, quadrants and flywheel. If the engine tends to race, the flywheel "lags behind" until the additional force has been supplied to overcome the inertia; this force causes the quadrants to partially revolve about their point of suspension, thus compressing the spring *E* and closing the throttle-valve by means of the bell-crank lever *H*. The objection to this governor is that it has to be of such large dimensions before it can satisfactorily work within the ordinary limits of speed, owing to the force closing the throttle being dependent upon the inertia of the flywheel.

Following closely upon the heels of this governor came several others, constructed upon various principles. Pinker's relied upon the movement of the ship relative to a suspended pendulum, as shewn in Fig. 2. Meriton's was upon the same principle as Silver's, but employed different means for obtaining the necessary movement to actuate the throttle. A. V. Newton invented a governor dependent upon the difference in speed between the main engines and a small engine kept running at a constant speed. But no very great advance was made until 1871, when Dunlop invented his governor.

Dunlop's. This governor consists, in its improved form (see Fig. 3), of a sea-cock at the stern of the ship opening into an air vessel or air chamber, so constructed that, by opening the sea-cock, water is allowed to flow into the air vessel and compress the air contained therein to a pressure equivalent to the head of water outside the ship.

From the top of the air chamber a pipe is led to the under-side of an air-tight elastic diaphragm, forming part of an apparatus in the engine room. On the top or upper-side of the diaphragm there is a spiral spring, with means of adjusting its compression to balance the air pressure below the diaphragm. From the centre of the diaphragm a connection is made to the slide-valve of a small steam cylinder, so constructed that its steam piston, which is connected by suitable gear to the steam valve of the engines whose speed is to be controlled, moves in exact accordance with the movements of the diaphragm.

The sea-cock being open, any variation of head of water outside the ship is accompanied by an inflow or outflow of water through it, and consequently a variation in the pressure of the air contained in the air vessel and under the diaphragm of the engine apparatus, causing the diaphragm to move through such a part of its travel as is requisite to enable the compression of spring and air pressure to balance one another again. Every movement of the diaphragm is followed by a corresponding movement of the governor steam piston, and consequently of the steam valve of the engines under control. The time required for the pressure to travel along the pipe from the sea-cock to the diaphragm is said to be very small, and the spring can be so adjusted that the diaphragm commences to fall, and the steam valve to close, when the tips of the propeller blades are anything from one foot to several feet under the water.

The most important feature claimed for this governor is that it will anticipate any increase in the speed of the engines so long as that increase is due to the propeller being out of water; but in the case of a shaft breaking it is of no use, the engines would then race as heavily as if there were no governor fitted.

In 1874 Lake invented a governor relying upon a principle of churning water in a drum to obtain a constant speed, with a mechanism for closing the throttle when the engines tend to race, but it was left for Churchill in 1879 to apply this principle in practice.

Churchill's.—A great number of marine engines were fitted with this governor, which was undoubtedly the best of its day, and one still finds them afloat on many of

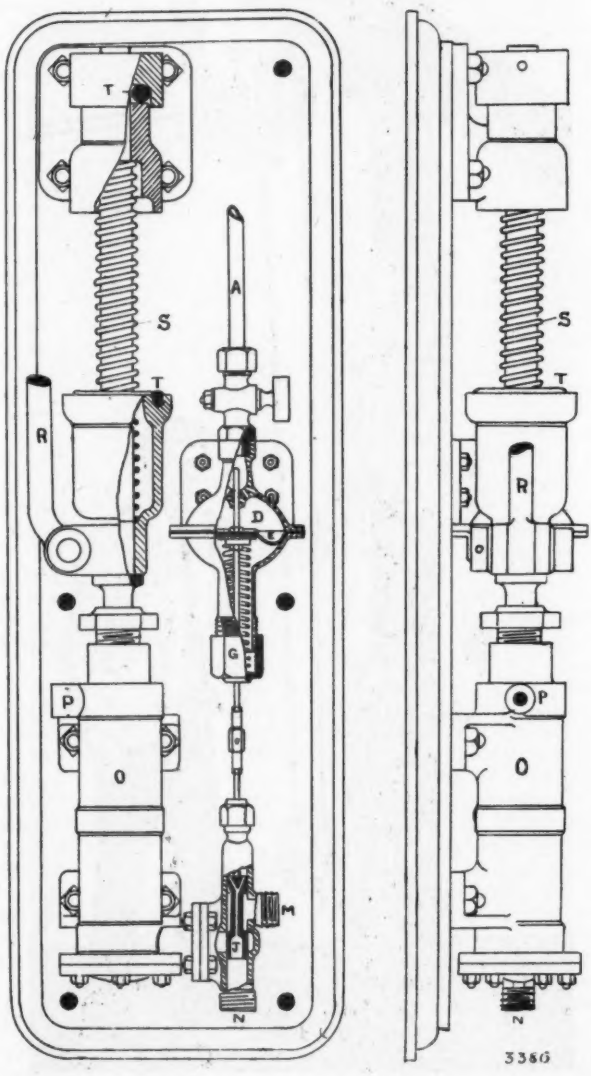


FIG. 5.—COUTTS AND ADAMSON'S MARINE ENGINE GOVERNOR.

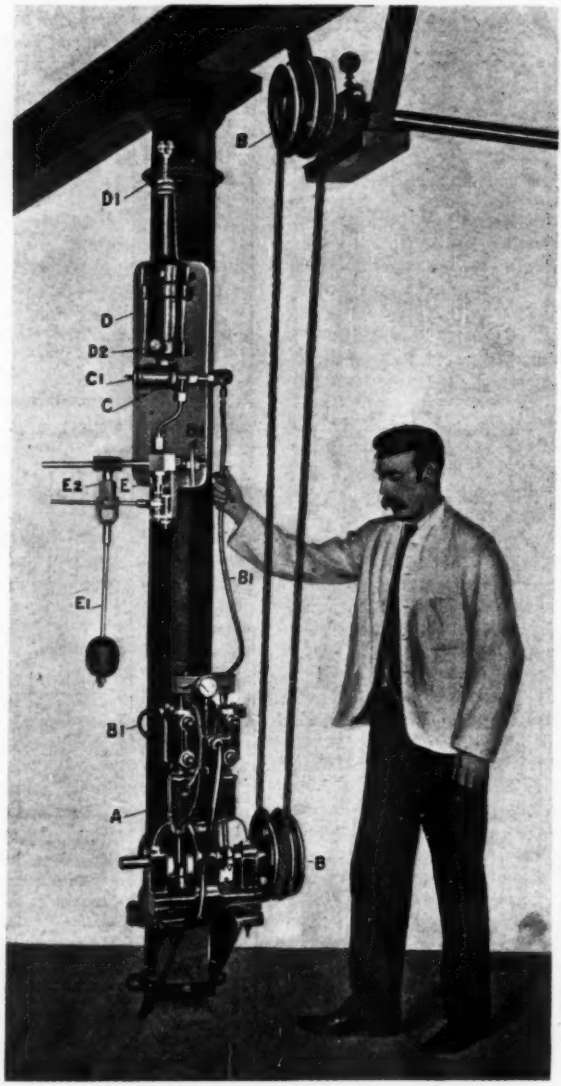


FIG. 6.—THE "THUNDERBOLT" MARINE ENGINE GOVERNOR.

the older boats. Fig. 4 is a sectional elevation, from which it will be seen that the main casting consists of a bracket for bolting on to the bulkhead or other support, carrying a depending bracket for the driving spindle; and at the further end is the water, or retarding cylinder, with baffles. Within this cylinder is a fan, carried by the fan spindle working through a gland and stuffing box. On the end of the fan spindle is a small cup, which has two pieces cut out of its sides so as to form a double cam. This cup works inside of a larger one (carried by the driving spindle), which cup has two parallel slots cut in it.

It will be noticed that there is no direct connection between the fan spindle and the driving spindle. Between these two is the intermediate spindle, a T-shaped piece, on the two short arms of which are four friction rollers, the coned rollers bearing on the double cams of the small cup; the other two friction rollers work in the parallel slots of the large cup. The driving-shaft is hollow at its inner end, and there is a slot cut through at right angles to its length. Into this hollow shaft the long arm of the intermediate spindle is inserted. Between the bearings of the driving-shaft and its cup there is a space left for a collar and movement in the axial line. A pin passes through the collar and through the slotted holes in the driving-shaft, thereby forming a bearing for the end of the intermediate spindle. The collar forms a bearing for the bell-crank lever, which is pivoted in a double jaw on the main bracket. The long arm of the bell-crank lever is held down by a spring. The short arm is connected with the slide-valve rod of the steam cylinder. The steam chest is at its rear end, where the cylinder is pivoted so as to swivel in an arc of 180 degs, thus facilitating the obtaining of as direct a lead as possible for the connection with the throttle-valve. There are steam connections on both sides of the steam chest.

It will be seen that this machine can be driven in either direction, as the cams on the fan spindle are double-acting. This is a great advantage, as it can always be driven with an open rope; not only so, but it has control over the engines when going astern. The driving spindle carries a V-shaped driving sheave, and also a loose sheave. When it is in action the power to drive the fan is transmitted from the large cup to the small cup through the intermediate spindle, causing it to mount the inclines of the cams, thereby forcing the long arm further into the hole in the driving-shaft and carrying with it the pin which passes through the collar and slotted hole, thus moving the collar and its skid and carrying with it the bell-crank lever against the tension of the spring. At the same time the short arm of the bell-crank alters the position of the small slide-valve operating the piston in the auxiliary steam cylinder. The movement of the intermediate spindle is controlled by the spring attached to the long arm of the bell-crank. This spring is adjustable by a thumb screw.

The principle on which this machine acts is very simple. On the one side you have work done in the water cylinder, on the other side the tension of a spring: the differential gear being the fulcrum or pivot, on which the two forces are balanced. If the work done in the water cylinder, by reason of increment of speed, exceeds the tension of the spring, the balance is upset and the throttle-valve is partially or wholly closed, and *vice versâ*. In this machine we have a governor of delicate and sensitive description for operating a very small slide-valve on the auxiliary steam cylinder, the piston of which does the heavy work of operating the throttle-valve of the main engine. In fact, the governor simply indicates when the steam cylinder shall do the work.

Some engineers maintain that to efficiently control a compound or triple-expansion engine other means must be employed than that of simply regulating the admission of high-pressure steam to the high-pressure cylinder, their argument being that the steam in the casing and the vacuum acting on the low-pressure piston would be sufficient to cause dangerous racing. It was to meet this argument that Messrs. Durham, Churchill & Co., introduced a "compound attachment" for use in connection with the

governor just described. It is the invention of Jenkins & Lee, and consists of an intermediate valve of special construction fitted into a pipe connected to each end of the low-pressure cylinder (almost similar to an indicator pipe, but larger). The pipe is fitted with a stop valve at the top and bottom, and the intermediate valve is operated by the governor, so that when the engine is throttled this valve is opened at the same time, thus throwing the low-pressure piston into equilibrium.

Couts and Adamson's. This governor, invented in 1880, works upon the same principle as Dunlop's, but has a different mechanism for causing the variation of head of water at the stern of the vessel to actuate the throttle-valve Fig. 5 shews an elevation, partly in section, of this governor. A stand-pipe is placed in the stern of the vessel with a cock at the lower end opening into the sea. The upper end of this pipe is connected to the pipe *A*, consequently any variation of pressure at the stern of the vessel, due to the different depths of immersion of the propeller, is transmitted to the box *D* and causes the diaphragm *E* to fluctuate. The diaphragm has a spring fitted to the underside, and the pressure of this spring can be adjusted by means of the nut *G*. A spindle passing through the diaphragm is connected with the valve *J*. If the pressure on the diaphragm is that due to the required head of water at the stern this valve *J* remains in its lower position so that the lower side of the piston in the cylinder *O* is open to the condenser by means of the connection on *M*. But, when the pressure on the diaphragm falls, the valve *J* is lifted and steam forces the piston up, *N* being connected to a convenient lead of main steam. The upper side of the piston is open to the atmosphere at *P* and the piston is connected to the throttle-valve by means of

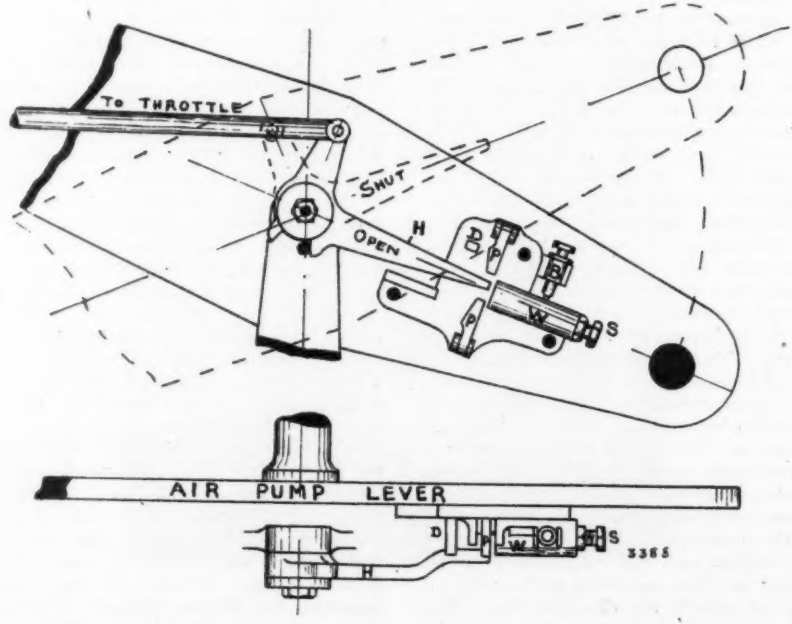


FIG. 7.—DETAILS OF ASPINALL'S MARINE ENGINE GOVERNOR.

the rod *R*, so that when the piston is at the top of its stroke the throttle is closed. The spring *S*, combined with the atmospheric pressure, forces the piston down again, when the pressure on the diaphragm again causes the valve *J* to shut off steam and open the lower end of the cylinder to the condenser. Rubber buffers are provided at *T*, *T*, to take up any knock when the piston reaches the top of its stroke. This governor possesses the advantages and disadvantages of the Dunlop governor.

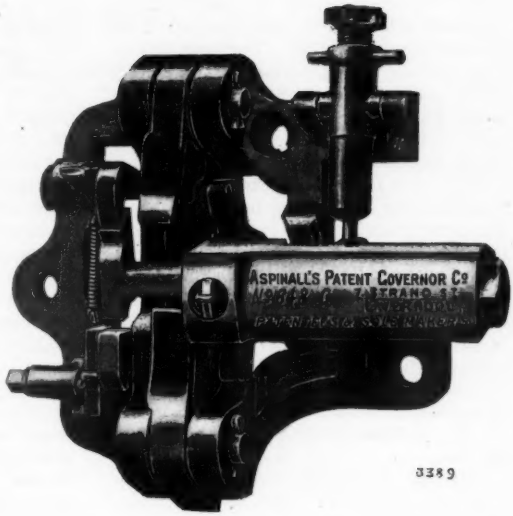


FIG. 8.—ASPINALL'S MARINE ENGINE GOVERNOR.

The "Thunderbolt." This governor (see Fig. 6) consists of a set of duplex double-acting air-compressors, a patent automatic adjustable regulator, and a cylinder containing a piston for controlling the throttle-valve. These parts are attached to any convenient place in the engine-room, and are connected by a $\frac{1}{2}$-in. copper pipe, through which the air is conveyed. The regulator has an equilibrium outlet valve *E*, which is operated by the pendulum *E*1, suspended from the adjustable sliding fulcrum *E*2. If the stern of the vessel rise out of the water, the pendulum *E*1 will assume such position as will close the outlet valve *E* and prevent the escape of air. Underneath the throttling cylinder *D* is fixed a quick-acting valve *C*, containing a small spring piston *C*1. This piston is adjusted to resist a greater pressure to the square inch, than the spring throttling piston in the cylinder *D*, consequently, when the air forces back the piston *C*1 it is admitted into the cylinder *D* at a pressure more than sufficient to force up the piston rod *D*1. When the air pressure becomes normal, the piston *C*1 returns to its original position, and allows a free escape of the air from the cylinder *D*.

When this governor is in action the air compressors *A*—driven from the main shaft by belt, or by any other means, to the patent clutch pulley *B*—force air at a predetermined uniform pressure through the pipes *B*1 and *B*2, having an outlet at *E*. Any tendency on the part of the engines to exceed the adjusted maximum speed would cause the air compressors to discharge more air than could escape through the adjusted outlet valve *E*, thus increasing the air pressure against the piston *C*1, which would be forced back, and the air admitted to the throttling cylinder *D*. As the stern of the vessel rises, the pendulum *E*1 operates and closes the outlet valve *E*, and the increased pressure forces back the piston *C*1, which allows the air to enter the cylinder *D*, and force up the piston rod *D*1, so as to close the throttling valve. With the return motion of the vessel the pendulum will act to re-open the outlet valve *E*, until the air pressure becomes normal. As the piston *C*1 returns to its forward position it opens the escape port for the air from cylinder *D*, and as the piston rod *D*1 returns it opens the throttle-valve. *D*2 is a safety-valve.

It will thus be seen that the action of the pendulum *E*1 causes the synchronous movement of the piston rod *D*1, and with

it the throttle-valve of the engine, thus anticipating the racing when the propeller is insufficiently covered. The same action also enables the governor to give the engine steam in time to prevent loss of speed when the propeller re-enters the water. The sliding fulcrum *E2* can be easily adjusted to suit the trim of any vessel. For instance, if the vessel using this governor is running against a head sea heavily loaded and low in the water, then the fulcrum *E2* should be fixed close to the outlet valve *E*, giving a short range to prevent the governor anticipating too early the propeller rising out of the water. If, on the other hand, the ship is floating light, the governor should be very sensitive and quick in anticipating; under such circumstances the fulcrum should be set to the greatest range from the outlet valve.

Aspinall's. This governor, as shewn in Figs. 7 and 8, is the latest, and no doubt the best of all marine engine governors. It relies upon the old principle of inertia, but is entirely new in its method of applying that principle to governing. One of the great points in favour of this governor is the fact that it is always ready to close the throttle valve immediately a predetermined increase of speed takes place, no matter from what cause, without using up energy as is the case with rope-driven governors. The only time this governor actually absorbs work or energy from the engines is when it is either closing or opening the throttle-valve. It can be adjusted so that an increase of a few revolutions per minute will cause the throttle to close, or if required it can be made to act only upon a much greater increase of speed; but in either case the throttle is opened again immediately the engines slow down to their normal revolutions, except in the case of a shaft breaking, or any other mishap which would cause serious racing, when an emergency gear comes into action and closes the throttle so that the emergency gear has to be taken out by hand before the engines can be re-started.

Referring to Figs. 7 and 8, it will be seen that this governor is extremely compact and simple. It is bolted to the air-pump lever, or if desired to a special rocking lever fitted for the purpose, and from there it is a simple matter to take a connection to the throttle-valve. It consists of a weight *W* mounted on a spindle parallel with, but a short distance from, its axis towards the lever. Therefore when the inertia of this mass, due to the reciprocating motion of the lever, is sufficient to overcome its weight, it will swing about its spindle at each stroke of the engine. But in so doing it causes either the top or bottom pawl, marked *P*, to swing outward, so that it strikes the lever *H* and closes or opens the throttle. Now, when the weight takes up its upper position, the lower pawl swings outward and closes the throttle by pushing the lever upward, as shewn dotted, and a small catch or detent holds the weight in this position until it is released by the detent striking the lever *H* as the governor swings downward on its return stroke. If the engines have then resumed their usual pace the weight will swing into its bottom position, and the top pawl will open the throttle on its next downward stroke; but if the speed is still above the limit the weight will remain in its top position, keeping the top pawl in and the throttle closed.

The emergency gear comes into action in the case of a tendency for a very excessive race, such as losing a propeller or breaking a shaft. A smaller weight is then thrown upward, and locks the larger weight in its top position and keeps the throttle shut.

The governor can be adjusted for small variations in the speed by means of the screw *S* and the spring *B*.

At first sight the action of this governor appears rather complicated, but it is simplicity itself when once understood. A good illustration of its action is to place a penny in the palm of one's hand and swing the hand up and down. When the speed is sufficient to cause the inertia of the penny to overcome the weight it is left behind, and the hand descends without it.

In conclusion, we would say that we have been on several ships fitted with this governor and find that they work admirably.

New Dynamometer for Road Traction Experiments.

At the last meeting of the British Association, those interested in road traction may remember that a report was presented by a committee which had been appointed at the 1901 meeting for the purpose of conducting investigations in connection with the resistance of road vehicles to traction. This report, which was presented by Prof. Hele-Shaw, the secretary, is of considerable value, as giving, for the first time, a concise summary of the work done on road resistance from the earliest time for which records are available. It does not, however, embody the results of any except preliminary experiments that were conducted with the special apparatus designed and constructed for the use of the committee, as, owing to various causes, the dynamometer was not completed until late in August. Experiments, however, are now being conducted to determine the relation between the tractive effort and the following, viz.: load, diameter of wheel, width and section of tyre, hardness of tyre (in the case of of pneumatics), effect of springs, and velocity for every type of road under all circumstances, and any other relations that may be suggested during the progress of the work. It is expected that by the next meeting the work will be sufficiently advanced to enable the committee to compare the results obtained by means of the new apparatus, with the formulæ and laws obtained by previous investigators that are given in the report of 1902.

The general arrangement of the new dynamometer is shown in Fig. 1. The apparatus comprises a castor frame *AA*, in which can be mounted the wheel *B* to be experimented on, a system of levers *CC*, for transmitting to a small plunger *E* the pull exerted on the wheel, and a recording pressure-gauge for registering the same, together with a recording tachometer.

The castor frame is of wrought-iron, and is rectangular in shape. Its sides are of channel iron, 4 ins. by 2 ins. by $\frac{1}{4}$ in., and are fastened together at the ends by wrought-iron plates, $\frac{1}{2}$ in. thick and 5 ins. wide, bolted on at the top and bottom. The total length of the frame is 6 ft., and as the end plates have three sets of holes drilled in them it can be arranged so that the sides are 10 ins., 14 ins., or 16 ins. apart, to suit the various widths of wheels to be experimented upon. The axle of the experimental wheel is mounted on springs, one under each side of the castor

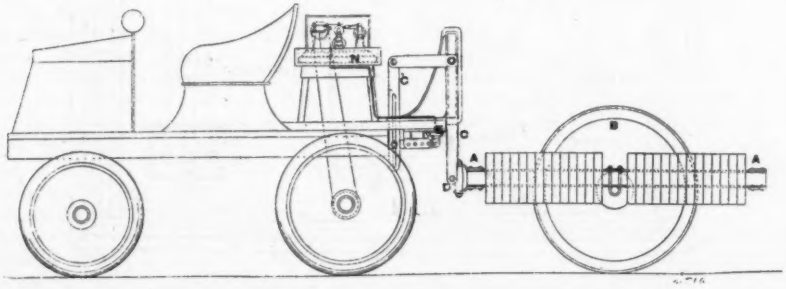


FIG. 1.—GENERAL ARRANGEMENT OF DYNAMOMETRICAL APPARATUS FOR ROAD TRACTION EXPERIMENTS

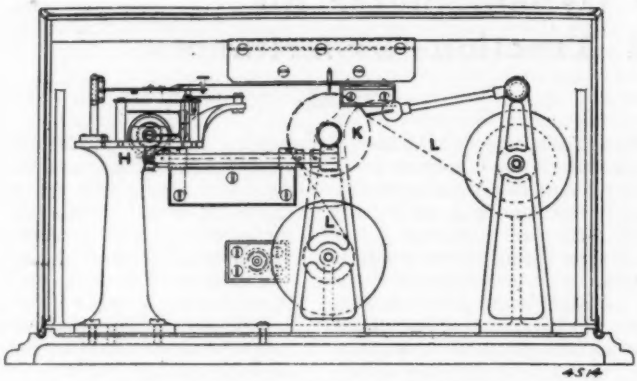


FIG. 2.—ELEVATION OF PRESSURE AND VELOCITY RECORDING INSTRUMENT.

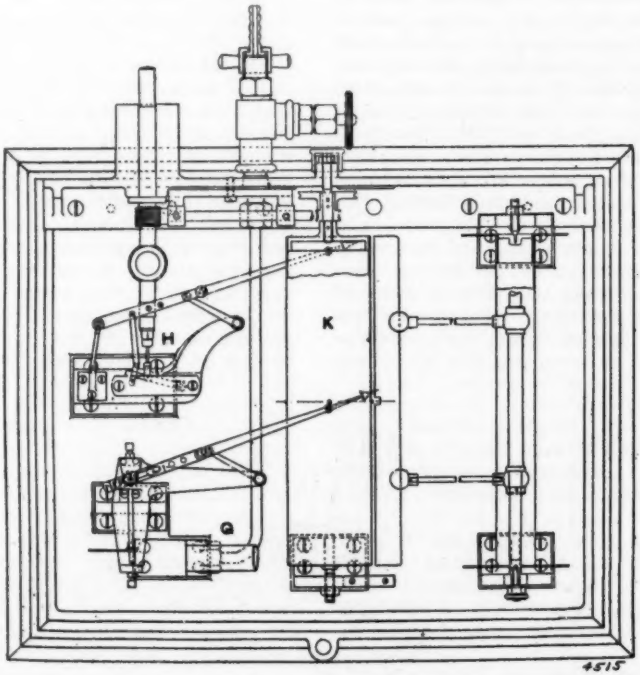


FIG. 3.—PLAN OF PRESSURE AND VELOCITY RECORDING INSTRUMENT.

frame. The springs are 3 ft. 2 ins. centres, and each consists of six plates $2\frac{1}{4}$ ins. by $\frac{5}{16}$ in. When light wheels and loads are used these springs are reduced to a suitable strength by the removal of some of the plates. If desired, the axle can be mounted on the frame without springs.

The method of loading the frame is by bolting a series of 28-lb. cast-iron weights to the channel iron-sides. These weights are each 2 ins. thick, so that when the scroll irons for the springs do not interfere 52 or so can be affixed, thus giving a load of 13 cwts. besides the weight of the frame and wheel. This would correspond to a load of about $3\frac{1}{4}$ tons on a four-wheeled vehicle. This arrangement of loading enables the weight to be varied by steps of 56 lbs., the weights always being arranged at equal distances on either side of the centre, so that the frame will never be out of balance. This frame is fixed to the levers which transmit the force to the water by a swivel joint *D*, so that it is quite free to vibrate or bounce vertically as over rough ground; and it can also follow the car freely round any curve without in any way affecting the records, but it is held so that the experimental wheel is always vertical.

The system of levers is so arranged that the frame can be raised or lowered to suit any diameter of wheel, or any angle of draught, without in any way altering the leverage of the mechanism. It may be described as follows.

A pair of similar bell-crank levers is mounted on a fulcrum, which is capable of being raised or lowered in a vertical slot formed in a steel casting mounted firmly on the back of the car. The distances from this fulcrum to the ends of the levers are respectively 14 ins. and 28 ins., the longer arm being normally vertical while the other is horizontal. To the shorter arm are attached two parallel vertical steel rods, whose length is capable of adjustment. These rods serve to transmit the pull on the frame to one end of a small horizontal lever, the hydraulic plunger being at its other extremity. The fulcrum of this lever may be moved to either of four positions, so that the pressure on the plunger is equal to one, two, four, or eight times the pull exerted on the castor frame. By having this arrangement it is possible to use the apparatus through a very wide range of experiments, say, for tractive efforts of from 5 to 500 lbs.

The plunger *E*, which is 2·6 ins. in diameter, presses upon a rubber diaphragm enclosing a space filled with water, and it is the pressure exerted on this water that is autographically recorded.

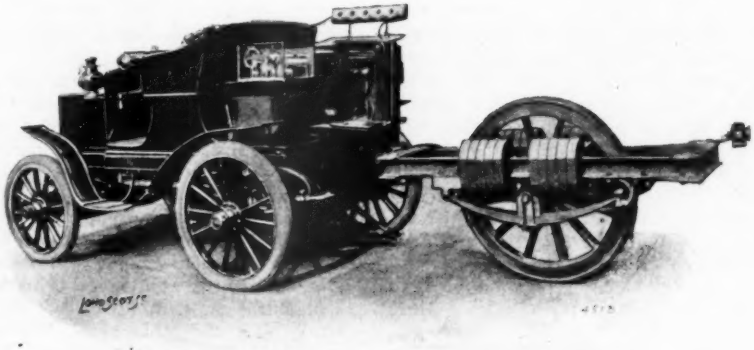


FIG. 4.—GENERAL VIEW OF DYNAMOMETER, WITH 40-IN. "LORRY WHEEL" IN FRAME.

FIG. 5.—GENERAL VIEW OF DYNAMOMETER, WITH OBSERVER IN POSITION. PNEUMATIC-TYRE WHEEL IN FRAME.

Two pipes are connected to the water space, one for transmitting the pressure to the gauge *G* (Fig. 3), the other being used for filling the system. An ordinary rubber bulb off a motor horn is filled with water and connected to the latter pipe, so that when the bulb is squeezed by the hand the water is forced through the system and out of a small hole in the end of the Bourdon tube. By this means all the air is expelled, and when sure that such is the case the system is closed and the water retained.

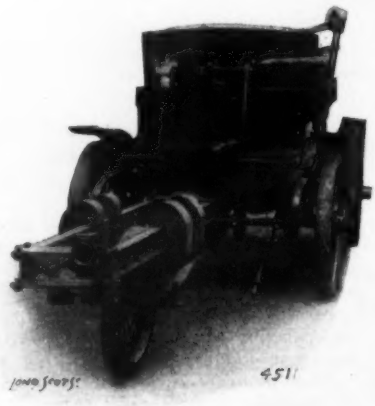


FIG. 6.—END VIEW OF DYNAMOMETER FROM THE BACK.

The recording apparatus was placed in the hands of Messrs. Schaffer & Budenburg, Limited, who have turned out a very good instrument. This apparatus is a combined recording pressure-gauge *G* and tachometer *H* (Figs. 2 and 3), mounted on one base and recording on the same horizontal drum *K*, which carries a band of paper *L L*, 8½ ins. wide, the graph of tractive effort-space being at one side of the paper while that of velocity-space is at the other side. The drum is driven off the tachometer spindle, and its motion therefore is in accordance with the motion of the car, a length of 10·3 ft. of the paper corresponding to a mile of road. The makers have worked out a very neat parallel motion, so that the ordinates of both graphs are straight.

The instrument is mounted in a rain-proof glass case, supported on a pneumatic cushion *N*, the drive to the drum and tachometer being through a flexible shaft. The arrangement has worked very well, fairly steady curves being obtained, even over rough roads, at high speeds. Stops are provided to prevent too great a movement of the levers, thus ensuring against undue shocks on the gauge. A revolution counter is provided for obtaining independently the revolutions of the experi-

mental wheel. This will act as a check on the record.

In performing an experiment, a given type of wheel is mounted in the frame and a run made over a piece of road of the desired type. Since the two graphs are side by side, the relation between tractive effort and velocity can be seen at every point of the run.; and, from those portions of the graph where the velocity is constant and of the required value, a mean tractive effort can be obtained.

The dynamometer was calibrated in the following manner. The car and dynamometer were placed on a smooth horizontal floor with a 40-inch lorry-wheel fixed in the frame. The car itself was prevented from moving backwards, and a given load was attached to a wire fixed to the wheel at the top and passing over the tyre, so that it hung vertically, thus tending to pull the frame away from the car. After a load was applied the apparatus was shaken to prevent it from sticking in any way, the paper meanwhile being uniformly moved until the pencil of the pressure-gauge had moved to its position of equilibrium. This was done with every reading. When the leverage of 8 to 1 was being calibrated, increments of 2 lbs. were used in almost every case from 0 to a total of 82 lbs. For the 4 to 1 leverage increments of 14 lbs. were taken, after 14 lbs. had been reached, the highest reading being 168 lbs.; the 2 to 1 leverage had increments of 14 lbs., the highest being 280 lbs., while the 1 to 1 leverage had increments of 28 lbs. up to a total of 530 lbs. Calibration curves were drawn for each leverage, and scales were drawn from these curves.

The tachometer was calibrated by driving it with an electric motor. The exact time of three revolutions of the drum was taken by means of a stop-watch for readings of 10, 15, 20, 25, and 30 miles per hour on the scale (three revolutions of the drum correspond to 315 revolutions of tachometer spindle). The mean diameter of the back wheels of the car was taken as 842 mm. when the car was normally loaded and tyres normally inflated; the diameter of pulley on back axle is 225 mm.; diameter of tachometer pulley 75 mm. Working out the speed from this data, a calibration curve was obtained, showing that the scale readings are reliable. It might be argued that if the driving wheels of the car slipped on the road, the tachometer is really reading higher than it ought to do; but as readings are only used for which the velocity is constant, very little slip may be expected; and since it is impossible for the driving belt of the tachometer to slip, thus giving too low a reading, it is not too much to assume that these errors will balance each other to some extent.

The method of operating the dynamometer and performing a trial is as follows:—The castor frame is pushed towards the car, so that the ram is as far out of the cylinder as possible, the bulb, having been previously filled with water, is squeezed by the hand, so that the water is forced through the cylinder, through the connecting tubing, and out through the opening in the end of the tube of the pressure gauge. This method of filling ensures the removal of all air. When all the air has been removed the cocks at each end of the system are closed. The stops have now to be adjusted, so that the maximum pressure of the water cannot exceed 100 lbs. per square inch, or else the gauge might be destroyed. After the adjustments are satisfactory a run is made to some given point over a given piece of road whose surface is of the desired type, a return run being made over the same road back to the starting point. By taking the mean values of the double journey, out and return, the effect of inclines is eliminated. The load is then increased and the route traversed again, and so on. For the first few experiments for a given load the speed was given a succession of values ranging from six to fourteen miles an hour, all in the outward run, just remaining constant at each speed for a sufficient distance to give a definite reading on the paper, and during the return journey the speeds were gone through in the reverse order, so that as near as possible the same piece of road was traversed at the same pace in each direction, this procedure being repeated for each load. This was not found very satisfactory on the whole,

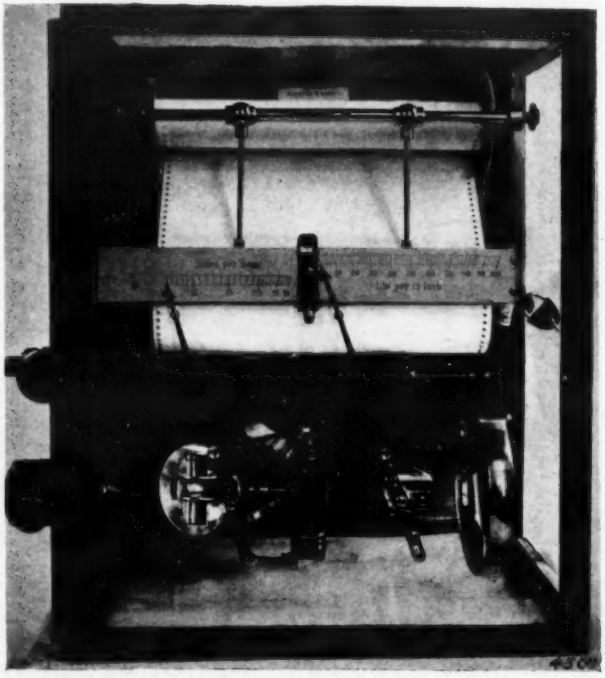


FIG. 7.—VIEW LOOKING DOWN UPON RECORDING INSTRUMENT.

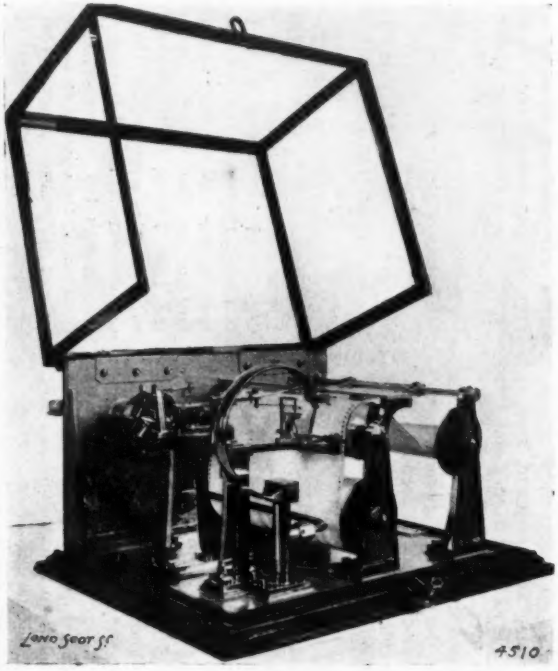


FIG. 8.—ANOTHER VIEW OF THE RECORDING INSTRUMENT.

so that for the succeeding experiments a given space was covered both on the outward and return journeys at a definite speed. The same journey was then traversed under a higher constant speed, and so on, until sufficient readings had been obtained to give a curve. This process was gone through for each load. This method, although slower than that tried at first, was found to give much more satisfactory results. As the dynamometer has only been completed such a short time, the trials are as yet only preliminary; the general results, however, tend to confirm those of previous investigators.

The behaviour of the apparatus is, on the whole, very satisfactory. The experimental wheel runs very steadily behind the car even with heavy loads at high speeds. The lorry wheel, however, runs better on setts than on macadam, oscillating sideways somewhat when passing over the latter at a high speed. The pneumatic tyred wheel runs exceedingly steady over all roads at all speeds.

The pneumatic cushion answers very well, allowing the instrument to swing gently from side to side instead of its having to suffer a violent vibration set up owing to the shaking of the car, due both to the engines and to rough roads.

Figs. 4, 5 and 6 show photographs of the dynamometer ready for use; Figs. 7, 8 are views of the recording instrument.

Photographic Surveying.

By J. T. McINTYRE, A.M.Inst.C.E.

It is somewhat remarkable that the fascinating and effective method indicated by the above heading should have hitherto found no place in the practice of the British engineer and surveyor, nor in the literature of his profession. France, Germany, Italy, Austro-Hungary, Canada, and the United States have all made use to a greater or less extent of the photographic method, and in the languages of the first four countries may be found not less than one hundred publications on the subject. Canada can boast an exceedingly thorough and excellent manual written by Mr. E. Deville, Surveyor-General, for the instruction of Dominion land surveyors; and in the United States, Lieut. Henry A. Reed published his "Photography applied to Surveying" in 1888, whilst the reports of the Coast and Geodetic Survey have contained more or less exhaustive notices on various occasions in later years. English literature is confined to mere references in the works of Bennet Brough and Lupton upon mine surveying, whilst other phases of camera-surveying have been dealt with by Mr. J. Bridges Lee, M.A., in papers read before the Society of Engineers, Society of Arts, and kindred institutions. Some references may also be found in the Proceedings of the Institution of Civil Engineers, but as they occur amongst the "Foreign Abstracts," they cannot claim to be original compositions. Insular prejudice, the vagaries of the English climate, and the fact that the excellent maps of the Ordnance Survey embrace ordinary requirements may all be suggested as reasons for the non-adoption of photographic surveying in Great Britain. But a truer explanation may probably be found in the want of literature upon the subject already referred to, and to the absence in such scanty records as exist of any survey work actually executed in England applicable to the needs of the engineer. It may be true that Britain affords a smaller field for photographic surveying than newer and less settled countries, and that the operations of the surveyor are restricted by the existence of the complete publications of the Ordnance Survey; but such considerations do not affect the merits of the art, which deserves a place in the curricula of technical colleges, if it may not find employment in the daily work of the English practitioner. Engineers trained in England proceed every year in increasing numbers to our colonies and dependencies, to foreign countries, and to the uttermost ends of the earth, and it is meet that they should be versed in the best methods of executing work with accuracy, economy, and rapidity. For certain classes of survey, the photographic method excels all others in these three essential qualifications, and for this reason it is desirable that its knowledge should be inculcated in those of the profession whose duties are likely to carry them to countries in an earlier stage of development than Great Britain.

Before going further, it appears appropriate to define, at least approximately, what is intended to be conveyed by the term Photographic Surveying. Briefly, it may be said to be the delineation of the earth's surface in horizontal and vertical projection from photographic images of the same; in other words, to resolve perspective views obtained by photography into plans and sections possessing any required degree of accuracy.

The use of an inversion of the laws of perspective was recognised nearly a century ago, and the officers of a French frigate, proceeding on a voyage round the world, were instructed to prepare their topographical maps by its means. As in this case the perspective views were

merely eye-sketches, the degree of accuracy attained would depend upon the skill of the sketcher, and the method must be regarded as weak when compared with those in which instruments are employed. Still, the idea of Beautemps-Beaupré contains the germ of modern methods, and with a view to securing the needful accuracy in sketching, Col. Laussedat, in 1854, employed the camera lucida, and subsequently the photographic camera, which solved all the practical difficulties hitherto experienced, and placed at the command of the surveyor a new and rapid means of delineating the earth's surface, which threatened to supersede the time-honoured methods then existent.

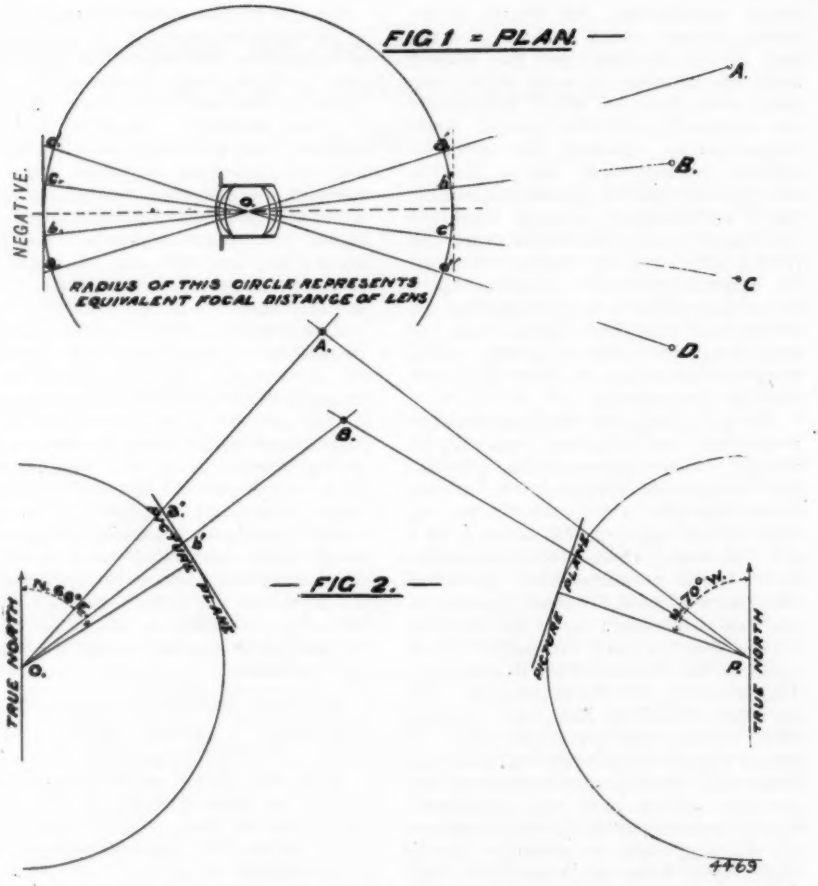
But photography was in those days less understood than at present, and with the wet plates then in use was at best a tedious and troublesome process; hence it happened that the new system of surveying only at first engaged the attention of a few enthusiasts, whose labours, successful to a degree in many cases, possessed little interest for the outside world. So startling a discovery could not for long escape attention, and the publication of some of the results achieved brought it into notoriety, with the consequence that in France, Germany, Italy, and Austria it came into use upon a practical scale. In recent years its application in France has diminished to such an extent that it may almost be said to have been abandoned; and in Germany its use is chiefly confined to obtaining plans of buildings. On the other hand, Italy and Austria have vied in extending the application of photographic surveying to most refined uses. In the former country the renowned Porro brought to the subject his acknowledged genius in optical problems, and although the spherical plates, with which he at first experimented, proved impracticable, he did much notable work, and vastly developed the system. It was ultimately adopted for the Ordnance Survey by Major-General Annibale Ferrero, and is still employed therein. An account of the work done and methods in use will be found in the Fotogramenetria of Paganini, a treatise of high value.

Some of the most successful applications of photographic surveying are to be found in Austria in the execution of mountain maps, and the method has also been employed by Vincenz Pollack, Chief Engineer of State Railways. Amongst English-speaking nations Canada takes first place, and upon irrigation projects a very considerable amount of surveying has been done with the camera; but before going further it appears desirable to supplement the definition of photographic surveying already given with some necessary particulars.

The process actually employed in the preparation of maps from photographs is not as intricate as would be the inversion of perspective previously referred to, and in its simplest form necessitates little knowledge of either perspective or descriptive geometry. Complete acquaintance with both is desirable, but in the exceedingly elementary presentment of the subject hereinafter contained the geometrical construction employed is so simple as to need but a single demonstration to fix it in the mind for ever. To begin with, it is necessary in taking views for topographical purposes to fulfil the following conditions:—

1. Camera to be accurately levelled.
2. Plate to occupy strictly vertical position when camera is level.
3. Lens, capable of yielding pictures free from distortion at their edges, to be used always at constant focus, viz., equivalent focal distance.
4. Means of recording on negative trace of principal vertical plane by hair or fiducial marks on back frame or plate-holders.
5. Means of recording on negative trace of horizon, intersecting with (4) in the optical axis and the lens produced, the intersection on the plate marking the "principal point" of the perspective.
6. Position of station-point to be known.
7. Azimuth of principal vertical plane to be known.

Assuming these conditions to have been



secured, the thick *solid* line in Fig. 1,* marked "negative," represents the photographic plate in plan; and the doublet lens to the right is assumed to be at "equivalent focal distance" from the plate—that is to say, in the position for parallel rays. *A*, *B*, *C*, and *D* represent in horizontal projection points in the landscape, and *a*, *b*, *c*, and *d*, the position of their images on the plate with reference to *x y*, the trace of the principal vertical plane, which passes through the optical axis of the lens at right angles to the plate. It is obvious that the angles *aOx*, *bOx*, etc., are equal to *AOy*, *BOy*, etc., and if a positive print be made and placed as shown by the thick *dotted* line, marked "positive" in Fig. 1, at the same distance from *O* as the sensitive plate occupied—viz., the equivalent focus of the lens—the points *a'b'c'* and *d'* will fall in the direction rays from the station-point *O* to *A*, *B*, *C*, and *D* in the landscape. Projecting the points *a'b'c'* and *d'* into the

* The assumption made by Fig. 1 that the cones of entering and convergent rays meet at a common focus in the centre of the lens is not strictly correct, but the error thus introduced is negligible, and will not affect the accuracy of the plot.

horizon of the picture by dropping perpendiculars from their images meeting the horizon line in $a''b''c''$ and d'' (identical with $a'b'c'$ and d' in Fig. 1, which is a horizontal projection), it will be apparent that the angles subtended between the principal vertical plane, whose trace is given by xy, and A, B, C, and D, will be known by measuring $a''Oy$, $b''Oy$, etc., with a protractor. Knowing the position of the station point O and the azimuth of the principal plane, it is now possible to commence plotting, and having fixed O and drawn the principal plane in its correct azimuthal direction, with O as centre and the equivalent focal length of the lens as radius, describe an arc of a circle at right angles to the principal plane, and tangent to the circular arc, draw to line right and left, to represent the picture plane, equal in length to the distances right and left of the edges of the plate from the "principal point" in the perspective, indicated by the intersection of the cross-hairs or fiducial lines. By measuring the distance along the horizon line of the picture from the principal vertical plane, right and left to a'' b'', etc., and setting off distances equal to them in the plot along the picture plane right and left of the principal plane, lines drawn from O and produced through the plotted points a'' b'', etc., will form true direction rays of A B, etc.

Assuming that from a second known station point, P, a negative has been secured under similar conditions, in which the natural objects A and B are included, it is only necessary to plot P correctly in its relation to O, draw in the circular arc and "picture plane" as before, to enable direction rays of A and B to be drawn from P; the intersection of these rays with those drawn from station O will give the positions of A and B in the plot, as shown in Fig. 2. Such, in brief, is the very simple construction by which points appearing in two photographs from different stations are horizontally projected in a map; but it should be stated that in so brief and elementary an exposition much has necessarily been omitted, and some errors introduced which will become apparent as the processes of field-work and plotting are considered in detail.

Something analagous to the process above outlined was first applied in Canada in the preparation of maps for irrigation projects. In carrying surveys for this purpose through Manitoba and the North-West territories, where the country is comparatively flat and topographical features scarce, ordinary methods were employed, and sections along the lines run with the compass or transit embraced all necessary information; but as the Rocky Mountains were approached, and the surface became broken, it was apparent that by these means a contoured map could only be produced at considerable outlay of time and labour, and that the cost would be prohibitive. Government required that a reliable map should be speedily available, and that it should be a cheap one. Accordingly the photographic method was introduced, and proved so successful that its adoption in other branches of survey work followed. The principal advantages that manifested themselves were the reduction of field-work to a minimum, and the means afforded of recording data sufficient for the plotting of just so much detail as the work in hand required. The first-named advantage was specially valuable in a country where the outdoor survey season only lasts about one-third of the year—approximately from the middle of June to the middle of October, though liable to curtailment at either end by late or early snow—and of this brief period one-half of the days are lost on an average through smoke, fog, rain, and snowstorms.

The second advantage is not less important; in the case of irrigation surveys it is requisite to know in the first instance if water can be brought to the point proposed, and if it can be run off, also what capacity is available for storage. Should the conditions prove favourable, fuller information is required to enable a detailed project to be drawn up. With ordinary methods it will be seen that two surveys are necessary, unless the first be taken so fully as to insure the record of all necessary data, with the risk of the site proving unfavourable, and a large amount of

labour rendered uselesss. As will have been apparent, the photographic negatives secure every possible direction ray, vertical as well as horizontal, and from these may be plotted just as much detail as is required to show that the proposed work is feasible or not. If the site prove unsuited for the purpose in view the wasted labour, both in the field and in the office, has been a minimum; whilst in the case of the project being considered feasible, the same photographs furnish data for the preparation of a map in any required degree of detail without the expense of further field work.

It may be urged against the photographic method that plotting is more laborious than ordinarily, but a comparison of cost will show that the saving in the field staff more than compensates for the extra expense in office-work. A case quoted by Deville compares the cost of the plane-table and stadia method with the photographic. It involves the assumption that with the latter three days' work in office are required to plot one day's work in the field, and that for every day spent in the field another is lost through bad weather, making a total of five days for the camera survey and plot. As regards the plane-table, assuming that work can go on whenever the weather is fair enough for the camera, which is not strictly true, and admitting that the plane-table surveyor can plot and draw in the field as quickly as the photographic surveyor can in his office with every convenience at hand, the same survey with the plane-table would require exactly the same length of time at actual work—viz., 4 days + 4 days lost by weather = 8 days. Allowing that the field parties cost the same amount daily (20·50 dols.), and that in the office the topographer working alone is paid 5 dols. per day, the comparison works out as follows :—

Plane-table—	
8 days in field at $20·50	$164
Camera—	
2 days in field at $20·50	$41
3 days in office at $5·00	$15
	$56

that is to say, the plane table survey cost three* times as much as the photographic survey, and its cost would be still greater if more detail in plotting were necessary. As regards the cost of photographic surveying per unit of area, reference may be made to Mr. J. S. Dennis's record of work done on the Canadian irrigation surveys, where the season's work in 1892 commenced June 29 and ended October 17. Of the 111 days intervening, 48 were lost through smoke, rain, and snow storms, and in the 63 days thus left 500 square miles were surveyed, giving an average of 8 square miles per working day, or 4·5 square miles daily over the entire period. The plotting to a scale of $\frac{1}{20000}$ ($3\frac{1}{6}$ ins. to a mile) was completed by the topographer before the commencement of the ensuing season, and included 100-ft. contours. The total cost was :—

Packer, $2·00 per day ; labourer, $1·50	$429·00
Transportation	578·50
Living expenses	394·71
Miscellaneous	76·98
Total	$1,479·19
Salary of Topographer, $1500 per ann. / Do. Assistant, $730 do. \	2,230·00
Grand Total	$3,709·19

equivalent to 7·42 dols. per square mile, or 1·16 cents per acre.

The plotting could have been carried to greater detail than 100-ft. contours, but these were sufficient for the work in hand; and, moreover, it was an office rule that the topographer should plot the whole of his season's work before going into the field again. If a detailed map of any particular area is required it can be prepared from the same photographic negatives by plotting more points to a larger scale, involving no additional field-work.

From what has been previously said it will be gathered that the fieldwork of camera-surveying consists in the record

* The case appears to be overstated in favour of the photographic method: if, as is admitted in the assumption, a plane-tabler can plot and draw in the field as quickly as the photographic surveyor can in his office, the work of the former should occupy no longer than that of the latter, viz., 3 days + 3 days lost by weather = 6 days at 20·50 dols. per day = 123.00 dols., or 2½ times the cost of the photographic survey, instead of 3 times, as claimed.—[Ed.]

upon photographic plates of perspectives of numerous points, to which may be drawn direction rays from known stations, by whose intersections points may be plotted in plan, in exactly the same way as is done with the plane-table, with the exception that with the plane-table the rays are drawn in the field as the objects are sighted with the alidade, whilst with the camera they are drawn in the office.

In the camera survey successive stations are occupied by the instrument, and at each a sufficient number of plates exposed to include all the features which are desired to be reproduced in the resultant map. The number of exposures will naturally depend upon the arc of the horizon included in the tract to be surveyed and the angular field of view of the lens without distortion, after making allowance for an overlap to allow of some objects near the edges of the plates appearing in consecutive views, which will permit of their being executed in case the record of the direction in which the camera was pointed be lost. Thus, if a lens having an angular field of view free from distortion of 40 degs. be employed, and allowing 4 degs. for overlap on either edge, the effective field will be reduced to 36 degs,, requiring the exposure of ten plates to complete a tour of the horizon.

FRONT VIEW OF BRIDGES-LEE'S PATENT PHOTO-THEODOLITE.

It is desirable that the survey should be based, as in plane-tabling, upon a system of triangulation which may either be prepared in advance or carried on concurrently with the photographic work. The selection of station-points involves other considerations than those deemed necessary in purely trigonometrical work, as it is desirable to locate them in situations commanding all the details to be brought out in the map, if this be possible, as well as to provide good intersections for plotting. At the same time an effort should be made to complete the necessary records upon as few plates as possible, bearing in mind that whilst it is necessary that every point to be plotted must appear on at least two negatives, and preferably upon three, there is no substantial advantage gained in going beyond the latter number. It will be found in broken

country that views from the triangulation stations will not always embrace all the features required for the map; as, for instance, where a spur conceals the view of a valley beyond, and in such cases subsidiary stations connected with the main stations must be occupied, or traverses made with prismatic compass and clinometer. The positions of subsidiary stations may be fixed by an azimuth and measured distance, or by interpolation, provided three main station-points can be sighted from it.

In Canada the triangulation is executed in advance with a transit theodolite, and the points thus fixed are subsequently occupied by the camera, and rounds of views taken; but if the camera be fitted with a tribrach, levelling screws, a pair of spirit bubbles at right angles, telescope, and horizontal and vertical circles, it is possible to carry out the triangulation and photography simultaneously with one instrument. The method to be adopted will generally depend upon the apparatus and men available, and it is not therefore possible to enunciate a general law; but to simplify operations in a first attempt it will probably be advisable to execute the triangulation in advance. In the simplest application of photographic surveying any well-made ordinary camera may be used, provided the conditions (1) to (5), enumerated on page 21, be observed, and the equivalent focal distance of the lens is known. This should be clearly marked on the brass rails, so that the camera front may be readily adjusted in this position, in which it will be solely used in survey operations. Conditions (4) and (5) may be secured by means of needle points, so fixed in the plate-holders that when joined up they will mark the traces of the principal vertical plane and horizon of the picture intersecting in the "principal point," viz., where the optical axis produced meets the sensitive plate at right angles. The needle-points will print out as short lines requiring to be joined up in the print to give the horizontal and vertical axes, or these lines can be produced in the negatives and prints by substituting cross-hairs so disposed as to press against the plate during exposure, or by placing a clear glass screen, on which the lines have been engraved, in front of the plate.

Under these conditions an ordinary camera can be used with detached spirit-level and compass for ensuring horizontality of the instrument during exposure, and recording the bearing of the principal vertical plane respectively. Where a triangulation system has been established in advance, the compass-bearing is not necessary if another station is visible, and care be taken in overlapping the views that distinctive points to the extreme right of one view are included on the left edge of the next adjoining exposure, it being assumed that the round of views is taken from left to right. Artificial signals should be used wherever station-points are not easily recognisable, or where natural objects are not available for overlaps.

Probably the most suitable instrument for all the purposes of photographic surveying is the photo-theodolite, as patented by Pollack, Laussedat, Bridges-Lee, and others. All these instruments are provided with levelling-screws and cross-bubbles for securing horizontality; they also possess horizontal and vertical circles, with clamp and slow-motion screws, lens fixed at constant focus, and means of marking on the negative the horizontal and vertical axes of the view generally by triangular metal points, but in the case of the Bridges-Lee instrument by cross-hairs, which are printed on every negative, and obviate the necessity of ruling lines on the prints by joining up the fiducial marks. None of these cameras have bellows bodies, and are strongly constructed of wood and metal, that of Bridges-Lee being entirely of metal, an aluminium casting being used, which ensures ample strength and rigidity with moderate weight. In Continental instruments the front of the camera is generally capable of movement in a vertical direction to enable high or low objects to be included, which would otherwise not appear, being beyond the angular range of the lens. Instead of an attached telescope, Finsterwalder uses an eye-piece on the back of the camera in conjunction with the photographic lens, which gives a

telescope magnifying from seven to eight diameters, the eye-piece being movable round a horizontal axis so as to be always directed towards the centre of the object glass, in order to obviate imperfect vision with inclined lines of sight, a necessary precaution, as the camera front is capable of considerable vertical adjustment, though negligible where the Goerz lens is used. With any of the instruments referred to the triangulation can be established simultaneously with the photographic work, and in so doing the remarks previously made upon the selection of stations require careful attention. It will generally be found that what are termed "well-conditioned triangles" in geodetic work (*i.e.*, containing no angle less than 30 degs. and none greater than 120 degs.) will give the best intersections for plotting. Naturally, the best triangle is the equilateral, and it should be adhered to as nearly as possible; and it may also be remembered that the nearer intersections approach to an angle of 90 degs. the more accurate will be the plotting.

So much being premised, triangulation stations having been selected and a base measured, work may commence. The conduct of the triangulation is the same as in ordinary surveying, and there seems little to add to what has already been said about the photographic work. The dark slides are presumed to be numbered serially, and as each plate is exposed, its number, the azimuth, or angles to other stations, and the distinguishing letter of the station, should be entered in the field book, with any further particulars deemed necessary, such as number of stop, condition of atmosphere, exposure, etc. To ensure pictures suitable for plotting from medium size negatives, a small stop, long exposure, and the use of a colour screen are recommended. It should be remembered that the views are to bear enlargement and yield sharp details. Glass plates of moderate rapidity, with a thick coating of emulsion, are preferable to very quick plates, and celluloid should be rigorously eschewed. Isochromatic plates are used by some surveyors, but actual experience will soon indicate to the novice correct practice in aperture, exposure, and make of plate.

Given a knowledge of surveying and of practical photography, the beginner will need all his patience and all his application to ensure successful results at the very first attempt, and it is with the view of rendering his path as easy as possible that the triangulation has been assumed to be executed, apart from the photographic part of the work. Deville attributes the non-adoption of photographic surveying largely to the failures of those who have tried with extemporised apparatus, and given up the attempt in despair. Besides which, qualities are necessary on the part of the topographer which are not called for in the ordinary work of the surveyor or the photographer, and which must be developed to ensure the skill and ability necessary to overcome the difficulties of the new art. "Unlike other methods," says Deville, "it presents nothing before his eyes to show the progress of the work or the gaps that may exist in it. His undeveloped plates are his only records. Every time he exposes one he must have present in his mind what it will give, what amount of information he can extract from it, what constructions he will apply, what further views are necessary, and how they will combine." The same eminent authority also advocates roughly plotting the triangulation in the field on which the stations occupied by the camera are to be marked, thus showing weak points in the survey, and enabling the surveyor to work with greater assurance.

Assuming that from a series of triangulation points a sufficient number of exposures has been made to include each of the points necessary to be produced in the map, on three plates in most cases, and prints having been prepared, the work of plotting may now commence upon the lines already laid down. The first point to decide is the scale of the map, and this will depend upon the purpose for which it is required and the amount of detail necessary to be brought out. On irrigation surveys in Canada, where 100-feet contours are considered sufficient, the map is plotted to a scale of $\frac{1}{20000}$, and on topographical surveys in France a scale of $\frac{1}{5000}$ has been employed for the plot;

between these limits any convenient scale may be chosen, though usually it conduces to greater accuracy to adopt for plotting a more open scale than is required in the finished map, and to reduce down to the latter by photographic reproduction.

Having selected a suitable scale, the triangulation system being laid down and the picture planes plotted at right angles to the principal vertical planes of the individual views, which must, of course, occupy their true azimuthal directions, the work of intersection begins. It may be remarked, however, that where the construction lines representing the traces of the principal vertical and picture planes are likely to interfere with the plotting of intersections, the former may be kept outside the plot by using enlargements from the original negatives, which will not only show the points to be plotted more clearly, but will increase the length of the distance line, according to the degree of enlargement. Thus if a lens having an equivalent focal distance of 9 ins. has been employed, and if the prints are enlarged four diameters, the distance line will occupy 36 ins. in the plot, causing the picture plane to fall outside the intersections.

The method of obtaining intersections has already been shown, but in actual practice, to avoid covering the paper with a multiplicity of direction rays, it is usual to employ fine silk threads, and plot point by point singly. Accordingly, in a pair of prints having points in common, the points to be plotted are each marked with a fine dot and numbered, the same point bearing the same number in each view. A strip of paper is then laid along the horizon of the view fixed in position by a line ruled at right angles to the working edge, which line is made to coincide with the trace of the principal vertical plane; the positions of the points to be plotted with their numbers are now transferred to the edge of the paper strip, and next transferred to the picture plane in the plot, the middle line coinciding, as before, with the direction line of the view. A similar process having been gone through on the second view, the horizontal projections of the points common to both views are available for plotting. This is accomplished by inserting a fine needle at the points indicating the two stations, and attaching by means of a loop a fine thread of silk; the other end of the thread is joined to a piece of elastic and the latter to a lead weight which permits of a sufficient tension being placed on the thread to ensure a straight line. The two threads being in position, they are accurately adjusted over point 1 in each view, and at their intersection a dot is made, and the number of the point recorded alongside; the threads are then directed to points 2, 3, 4, etc., in succession, and as each intersection is made the points are laid down in plan, each bearing its distinguishing number. The process is continued until sufficient points are plotted to reproduce in the map as many or as few of the features in the landscape as are considered necessary for the purpose in hand. The foregoing method has been extensively employed for plotting photographic perspectives, and with satisfactory results, but it may be stated that more refined processes are also used. A paper read before the South African Philosophic Society by Mr. H. G. Fourcade, and recently published in *Nature*, describes a stereoscopic method of photographic surveying, in which photographs are taken with a surveying camera, at a pair of points, the plates being exposed in the vertical plane passing through both stations. A special feature in the camera is a réseau, or graduated back frame, giving the means of measuring the coordinates of any point on the plates with reference to the optical axis. This back frame is hinged in front of the plate, against which it is pressed by a spring, and its image is impressed upon the plate by exposure to sky light reflected through the camera lens, after which it is moved out of the way for the exposure of the picture itself. After development and fixing, the negatives or positives from them are viewed in a stereoscopic measuring machine, which, by combining the pictures, renders possible the instant identification of any point common to the pair of plates. Movable micrometer wires traverse each field, and pointings may be made simul-

taneously with both eyes. The readings of the micrometers, referred to the réseau, give the three co-ordinates of the point by direct multiplication by, or division from, constants for the plates, which depend only on the focal length of the camera lens and the length of the base. When a sufficient number of points have been plotted from their co-ordinates contour lines may be drawn. The ingenuity of the apparatus above described is undeniable; but notwithstanding its attraction for the scientist, practical men, such as Laussedat and Deville—the former of whom elaborated the photographic method, and possesses probably the clearest conception of its essential features, while the latter has executed the largest surveys hitherto achieved by its use—unite in condemning such refinements of method and calculations.

(To be concluded.)

Laundry Engineering.

By F. J. ROWAN, A.M.Inst.C.E.

(*Continued from page 419, Vol. VII.*)

THE use of "wringers," so-called, but more accurately roller squeezers, constitutes the first step in the process of drying; but the function of such machines is properly that of removing merely the surplus water held by the fabrics. Although the action of wringing as carried out by hand is not imitated in these machines, so that the fibres of the materials treated are not subjected to the same twisting strain, yet the squeezing may be overdone and so may produce practically the same straining effect; and there is the added danger of hard substances, such as buttons, being crushed or even forced through the cloth, or through the india-rubber squeezing surfaces, by the pressure of the rollers.

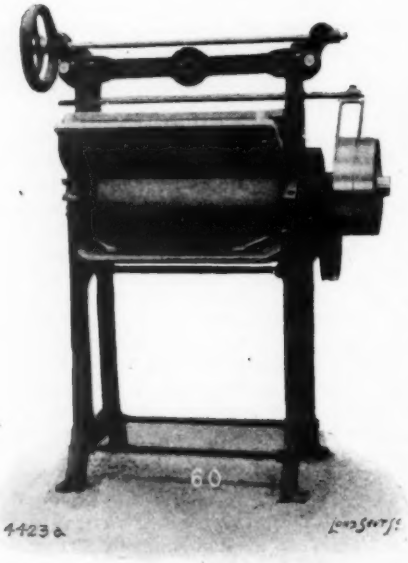


FIG. 1.—TYPE OF WRINGER IN WHICH PRESSURE IS OBTAINED BY SPRINGS AND LEVERS.

The pressure is obtained in different methods according to the construction of the machines, levers with weights at the foot of the machine being used by Messrs. T. Bradford & Co., Messrs. Manlove, Alliott & Co. making use of a strong plate-spring, with hand-wheel and screw for adjustment; whilst in Messrs. Summerscales' machine in Fig. 1 there is a combination of spiral springs with levers at the top of the framing, where there is also a hand-wheel for adjusting the pressure.

Fig. 2 shows a method by which such machines are combined with rinsing and blueing troughs in the work of extensive laundries.

The use of centrifugal machines, or "hydro-extractors," is now universal in steam laundries, and for rapidity and completeness of the extraction of water from the fabrics so treated, they leave little to be desired. They are made by all the leading laundry engineering firms, but have been a speciality with such engineers as Messrs. Watson, Laidlaw & Co. for several other industries before their use in laundry work became general. Fig. 3 shows a specimen of the under-driven pattern made by the Cherry Tree Machine Co., Ltd., with a belt drive from an overhead shaft, whilst in Fig. 4 we have one of Watson, Laidlaw & Co.'s under-driven machines fitted with an electro motor—the advantage of this arrangement consisting in its compactness and absence of belts.

Fig. 5 shows the ordinary form of overhead driven or self-balancing suspended machine, arranged with an electric drive, the same design being arranged for either a small engine or belt drive, with electric

drive, whilst others are arranged to be driven by a water motor. The framing in this latter case is arranged so that the machines may be placed alongside a wall instead of standing out on the floor of the laundry.

The most recent and complete system of safety covering is shown, closed, in Fig. 6 and, open, in Fig. 7. This safety cover is so connected with the starting and stopping valves of the water motor, and interlocked with them, that the machine must be at rest before the cover can be opened, so that it affords the maximum of safety to the attendants. All these latter machines are of Messrs. Watson, Laidlaw & Co.'s manufacture. Some firms use friction drives, and there are also many varieties in design and position of the motor used.

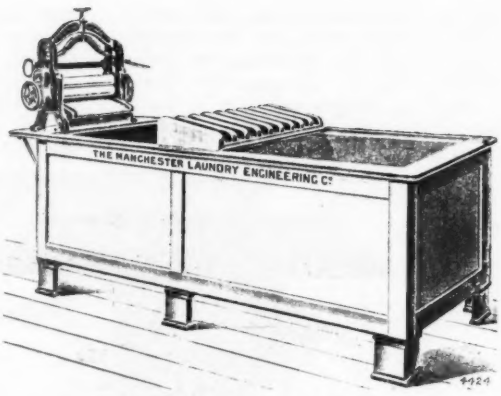


FIG 2.—COMBINED WRINGER AND RINSING AND BLUEING TROUGH

The final drying or airing is carried out in drying closets by means of currents of heated air, but ironing machines are now so arranged that they perform a substantial part of the process of drying, besides the smoothing or glazing actions due to their pressure on the fabrics. The ironing by machinery is performed by rollers, or by a combination of rollers, with flat or cup-shaped tables or beds The rollers are generally heated, and frequently the beds and tables also. Probably the oldest form of ironing machine was founded on the Scotch or roller mangle, but was more directly derived from the calendering machine. The most modern ironers are, however, modifications of the curved bed machine invented by Decoudin, whose name they still bear. Fig. 8 illustrates such a machine with one roller and its concave bed, and Fig. 9 shows the four-roller design which is used in large laundries. As at first introduced, the curved or cup-shaped bed was not ventilated, but later machines have embraced various improvements designed to remove the vapour formed from the moisture in the fabrics by the heat of the steam in the rollers and beds of the ironers. Sometimes the cup is inverted, and lateral motion of the rollers or bed of the machine has also been used to assist in putting a gloss on the articles ironed in these machines. Endless bands have been used in conjunction with rollers and with steam chests or curved boxes which are stationary, but the tendency is evidently in the direction of the simpler roller machines.

For articles which are starched and require a high gloss or polish, different

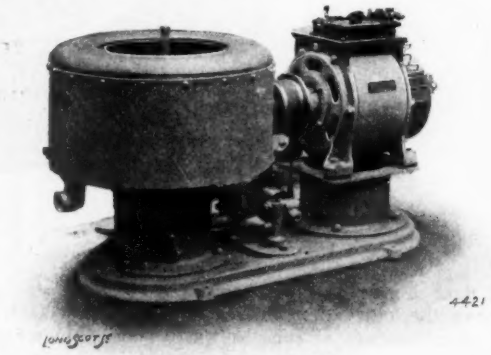


FIG. 4.—MOTOR-DRIVEN HYDRO-EXTRACTOR.

machines are used, amongst the newest designs of these being the moving-table machines and the overhung two-roller machine. Fig. 10 illustrates the former of these in designs by D. & J. Tullis, while others have the addition of a dust-screen to preserve the work from specks of dust during ironing; and Fig. 11 shows the other design as applied by W. Summerscales & Sons to "body" or skirt ironing. A similar form of machine is also used for collar, cuff, and even neck-band ironing. It is doubtless in these finishing processes that the greatest amount of damage is done to the fabrics treated, and every precaution that ingenuity can devise should be introduced to prevent rough usage. Chemicals used in the washing process, and mixed with the starch, in order to hasten both the cleansing and the gloss-forming, tend to weaken and destroy the fibre of the materials so treated, and hence the greater necessity for the gentlest treatment by finishing machines.

FIG. 3.—UNDER-DRIVEN TYPE OF HYDRO-EXTRACTOR.

Like all the other departments of laundry

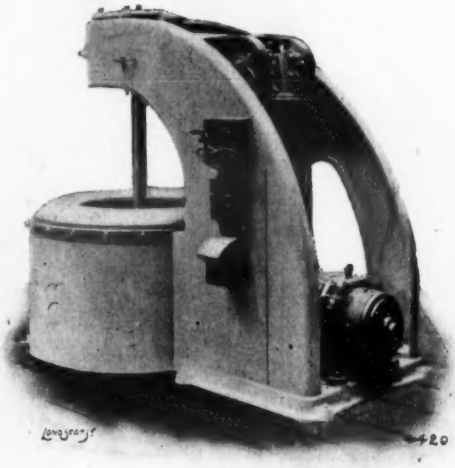


FIG. 5.—TYPE OF OVERHEAD-DRIVEN HYDRO-EXTRACTOR.

FIG. 6.—PATENT WATER-DRIVEN HYDRO-EXTRACTOR, FITTED WITH WOOLLEY'S PATENT SAFETY CONES. COVER IN SECOND POSITION, WATER ON, BRAKE OFF, COVER CLOSED, MACHINE IN MOTION.

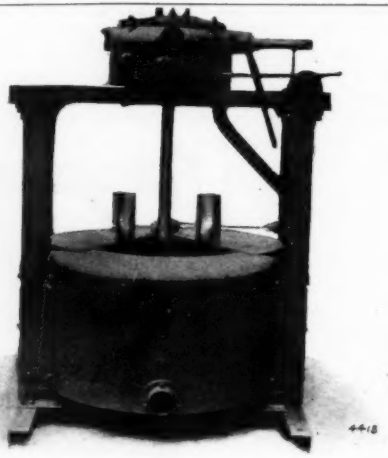


FIG. 7.—PATENT WATER-DRIVEN HYDRO-EXTRACTOR, FITTED WITH WOOLLEY'S PATENT SAFETY CONES. COVER IN FIRST POSITION, WATER-VALVE SHUT. BRAKE OFF, COVER OPEN TO ALLOW ATTENDANT TO LOAD THE BASKET.

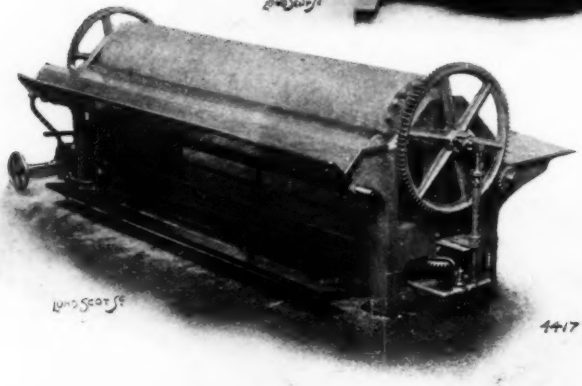


FIG. 8.—DECONDEN IRONING MACHINE.

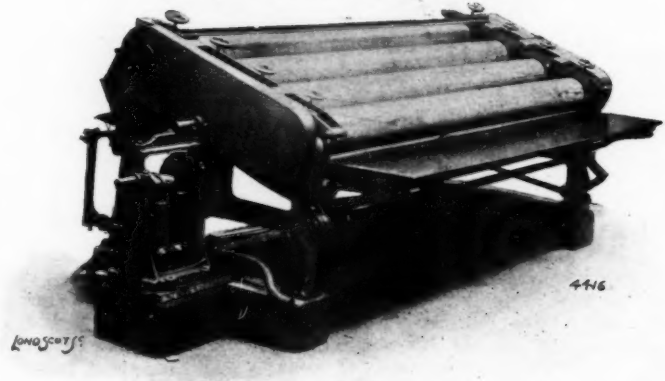


FIG. 9. FOUR-ROLLER DESIGN OF IRONING MACHINE.

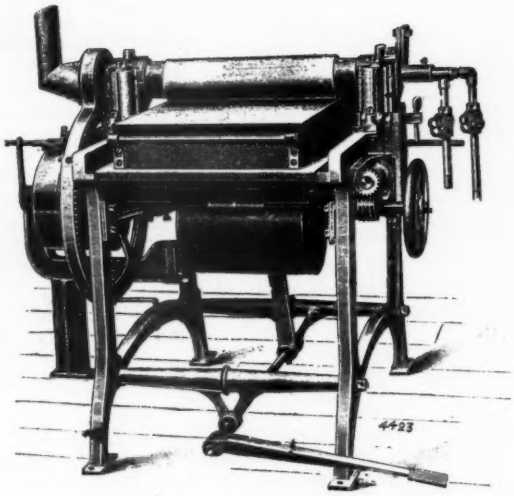


FIG. 10.—MOVING TABLE IRONING MACHINE.

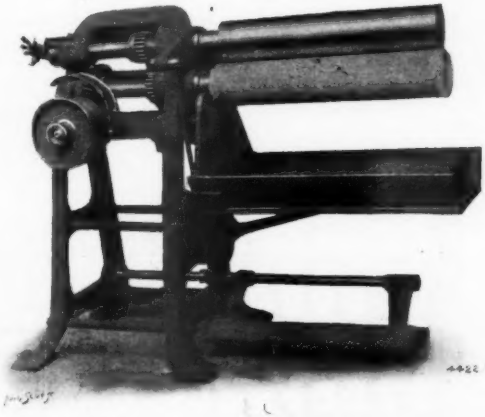


FIG. 11.—OVERHUNG TWO-ROLLER IRONING MACHINE.

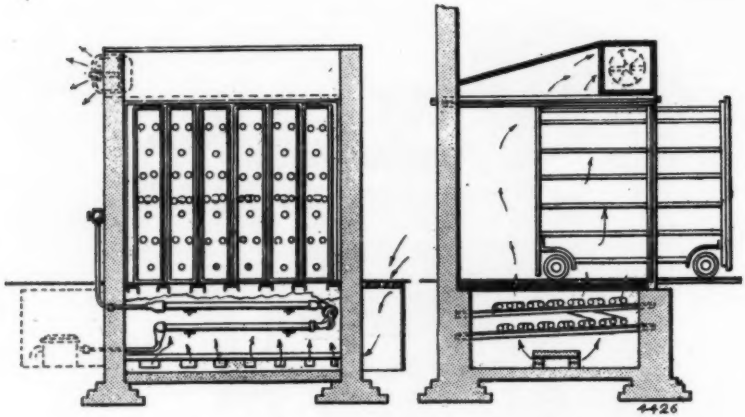


FIG. 12.—METHOD OF WORKING VENTILATED DRYING-CLOSETS BY FANS, VACUUM SYSTEM.

engineering work, the drying or airing room has given scope for the exercise of ingenuity and for the application of different systems and various designs. In its elements the drying chamber is simply a closet in which the clothes or other articles are hung and exposed to the action of heated air; but merely to shut up the clothes in a closed chamber filled with hot air, which is not changed and in which they are baked, is not by any means so good as to expose them to an abundant current of fresh heated air. Hence there are drying rooms in which the movement of air is produced by chimney draught, and others in which fans are used, either on the vacuum or on the plenum system. Then there is the question of the best method of producing the hot air, whether by steam-pipe coils or by a separate furnace. The movement of the clothes has also to be considered, and the different temperatures required by different classes of goods.

Figs. 12 and 13 show diagrammatically the two methods of working ventilated drying closets by fans, the former being that by induced draught (or the vacuum

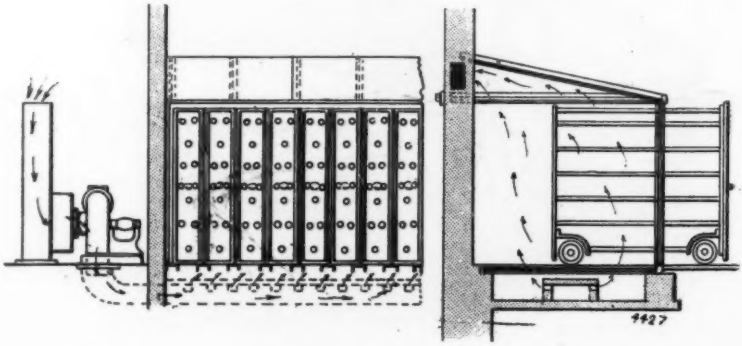


FIG. 13.—METHOD OF WORKING VENTILATED DRYING-CLOSETS BY FANS, PLENUM SYSTEM.

ystem), and the latter by forced draught (or the plenum system). Steam-pipe coils are employed for heating the air, placed below the floor in the one case and in a casing alongside the fan in the other; and draw-out racks or clothes-horses are also employed.

Where fixed or radial "horses" are used, it is necessary for the workers to enter the hot room to remove the clothes and to hang up others. Drying closets so arranged and heated by a separate stove, except in rare cases, do not form so satisfactory an arrangement as the mechanically ventilated draw-out rack system. It would involve a large demand for space were these questions to be discussed here, or the additional one of the best direction —whether up, down, or across—for the currents of heated air in the drying closets. There are many interesting points connected with all these questions, and, as usual, opinions on both sides of most of them. In general, economy in working and in space will be secured by the use of exhaust steam or waste heat to warm the air required; by the draw-out rack system; and by making the closets in two storeys, so that differences of temperature can be obtained readily.

(To be concluded.)

Electrical Equipment of the Antwerp Steel Works.

FEW recent electrical power installations are of more interest than that of the new iron and steel works on the banks of the Scheldt, near Antwerp. These works are to be of very large dimensions, and as the work is being pushed forward with all possible speed the whole plant will be complete in a short time, part of it having already been working some time.

The works include a tube shop with an annual output of from 40,000 to 60,000 tubes from 1½ in. to 40 ins. diameter; a blast-furnace plant; steel works with a complete roll train outfit; iron and steel foundries; machine, boiler, fitting, pattern, carpenters', smiths', and repair shops; boiler-house and power-house. When fully employed the daily requirements of the plant will amount to 4,200 tons of iron ore, 1,050 tons of limestone, 2,100 tons of coke, 3,000 tons of coal: all this material will be handled by means of electrical power. The coke works, with recovery of bye-products, is supplied with a washery and coal-mixing plant; in addition to this, there will be a plant for transforming the refuse from the washers into briquettes. A cement factory, with a daily output of 100 tons, will convert the blast-furnace slag into building or paving stones.

The total power required to operate the plant in full swing will be no less than

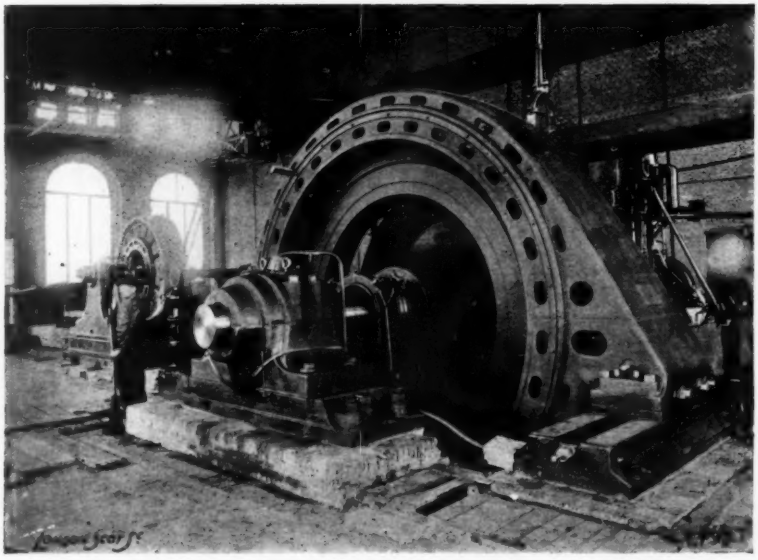


FIG. 1.—ONE OF THE 900-KILOWATT THREE-PHASE WESTINGHOUSE GENERATOR SETS DRIVEN BY MARINE TYPE ENGINE.

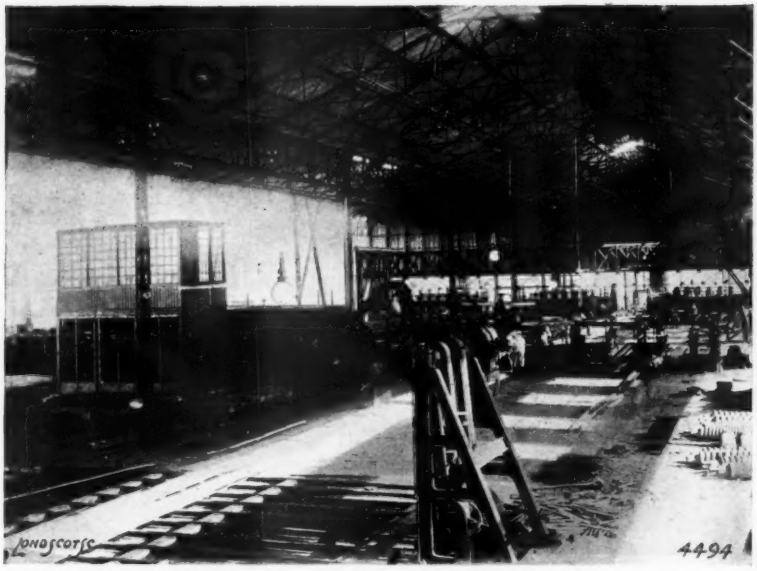


FIG. 2.—GENERAL VIEW OF MILLS OPERATED BY POLYPHASE INDUCTION MOTORS. FINISHING MILLS IN FOREGROUND, FLY-WHEEL FOR ROUGHING MILLS IN BACKGROUND.

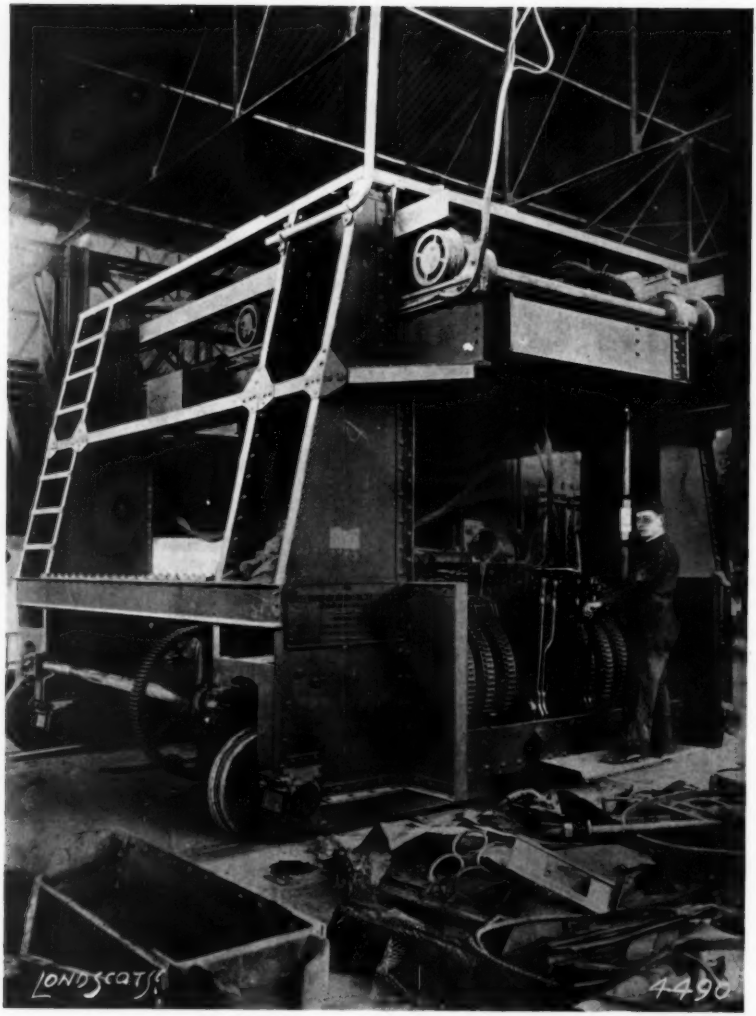
30,000 h.p., motor driving being employed throughout. The contract for the power equipment was secured by the Westinghouse Electric and Manufacturing Company, and Westinghouse motors and generating sets, etc., are to be installed. The present plant is of 2,200-kilowatt capacity; the two main sets consist of 900-kilowatt Westinghouse alternators coupled to 1,500-h.p. marine-type engines, running at 187 revolutions per minute. These engines were originally installed on a British torpedo boat, but have been reconstructed and fitted with Sisson speed regulators; the cylinders are of 22, 32 and 46 ins. diameter, and surface condensers are employed, the water circulation being effected by a centrifugal pump. The generators are three-phase machines of the Westinghouse rotating field pattern, working at 2,200 volts and 50 cycles per second. Fig. 1 shows one of these sets in operation. The third generator, which has only been put down temporarily as yet, consists of a 400-kilowatt machine, belt driven from the main generators. It is intended later to drive this machine by means of a tandem compound gas engine, using blast-furnace gas, and it is probable that eventually a very large proportion of the plant will be gas driven, and thus great economy will be secured. In the power-house itself a 40-h.p. motor operates the air compressor; a 13-h.p. motor the Benny automatic stokers; two 20 h.p. motors operate the air pump of the condensers; and three motors operate the 30-ton crane which spans the engine room, one 40-h.p. for lifting, one 20-h.p. for moving the trolley, and one 30-h.p. for traversing the crane. In addition to these there are two 21-h.p. motors for driving the feeder pumps of the water works, and one 65-h.p. motor for the railway which will transport coal from the barges on the Escaut river. All these motors are at present supplied from a transformer substation, located in

FIG. 3.—325-H.P. MOTORS, BELT-CONNECTED TO 30-TON FLY-WHEEL, DRIVING BLOWING MILL.

the power-house, which also supplies current for the lighting circuit of the works, comprising 200 Körting arc lamps and 500 incandescent lamps.

The main switchboard consists of six panels; one exciter panel (two 25-kilowatt Westinghouse steam exciters, working at 350 revolutions per minute and 220 volts, are installed), two generator panels, and three distribution panels, one for the rolling-mill circuit, one for the power circuit in the shops generally, and one for the lighting circuit. There are four transformer substations in the works, the only motors operating at full generator voltage being those for the rolling mills. Two sets of high-tension bus bars are provided, one being used only for the rolling-mill circuit, and thus this circuit, with its heavy fluctuations, is kept independent of the other supply circuits.

The most novel and interesting feature of the works is the use of motors for driving rolling mills. Hitherto it has been thought that the enormous variations of load put this class of work outside the sphere of motor driving, but the Westinghouse engineers succeeded in overcoming these difficulties, and these roll trains have now been in operation for some months without trouble being experienced. The mills in use at present consist of one roughing or blooming mill, and two finishing mills; on Fig. 2 one of the finishing mills is seen on the right, the other is to the left, hidden by the motor shed, etc.; the 30-ton fly-wheel of the blooming mill is prominent in the background. This blooming mill, which is of two stands, has 24-in. rolls, running at 70 revolutions per minute, and is belt driven by a three-phase induction motor of 325-h.p. capacity, with a normal speed of 300 revolutions per minute, which can be reduced 25 per cent. by means of a controller without reduction of full-load torque. The fly-wheel weighs 30 tons, great inertia being necessary to smooth out the variations in demand on the motor. The two stands of the mill take respectively 880-lb. and 450-lb. billets, each stand supplying one of the five-stand three-high finishing mills. The driving gear for this mill is shown in Fig. 3.



Machine at the Antwerp Steel Works for charging furnaces operated by 4 Polyphase Induction Motors

The two driving motors for the finishing rolls are contained in the little wooden house shown in Figs. 2 and 4. Near this house will also be seen a switchboard elevated on a platform; from this board are controlled the rolling-mill motors, and also the general motor and lighting circuits in the rolling-mill building. The larger finishing mill has 14-in. rolls, and takes 3¼-in. blooms rolled from 880-lb. billets; the smaller has 10½ in. rolls, and takes 2⅞-in. blooms rolled from 450-lb. billets. These two are driven by 450- and 325-h.p. motors respectively, being connected by solid flange couplings; a 12-ton flywheel is provided in each case to give the necessary inertia. One of these flywheels, and also the flange coupling, the bearings, which are very large, part of the mill, and the control switchboard, are shown in Fig. 4. Fig. 5 shows the 450-h.p. three-phase induction motor which drives the larger finishing mill.

These motors are controlled by means of rheostatic adjustment of the rotor resistance. Railway type controllers are used, containing a main reversing switch for the primary circuit, and appropriate contacts for throwing resistance into the secondaries. Three separate drums are used for the three wires of the three-phase system; the resistances are of iron, and allow of a reduction of 25 per cent. on the normal speed in fifteen steps.

It has not yet been possible to determine the exact amount of power required to roll the different sections of iron, as slightly tightening the roll train doubles or even trebles the power required to roll similar sections. But, roughly, the blooming mill absorbs an average power of from 75 to 100 kilo-watts, the smaller finishing mill from 130 to 180 kilo-watts, and the larger from 200 to 220 kilo-watts. The results altogether have been most satisfactory to the installing and operating engineers, as well as to the proprietors.

The five main aisles of the boiler shops are bridged by nine electrical cranes of capacities varying from 6 to 30 tons, and spans from 42 to 82 ft. The repair shop and the foundry have each two cranes of

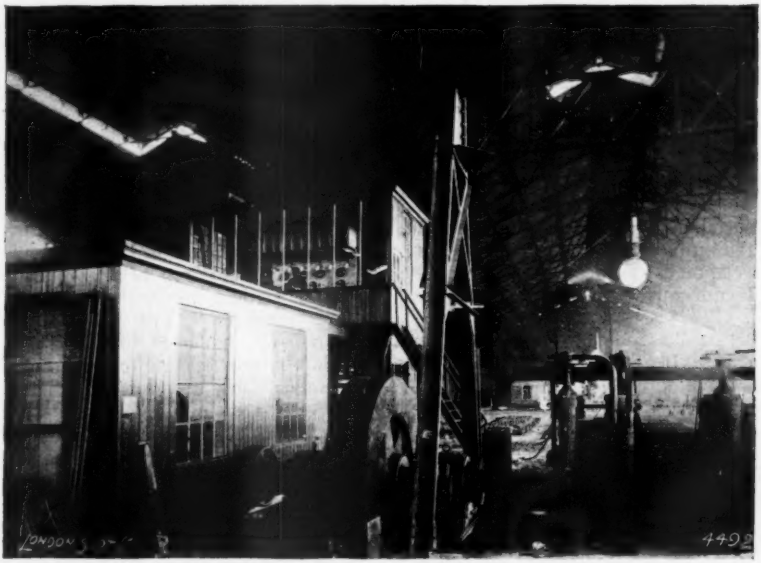


FIG. 4.—12-TON FLY-WHEEL TO PROTECT MOTOR FROM SHOCKS FROM FINISHING MILL.

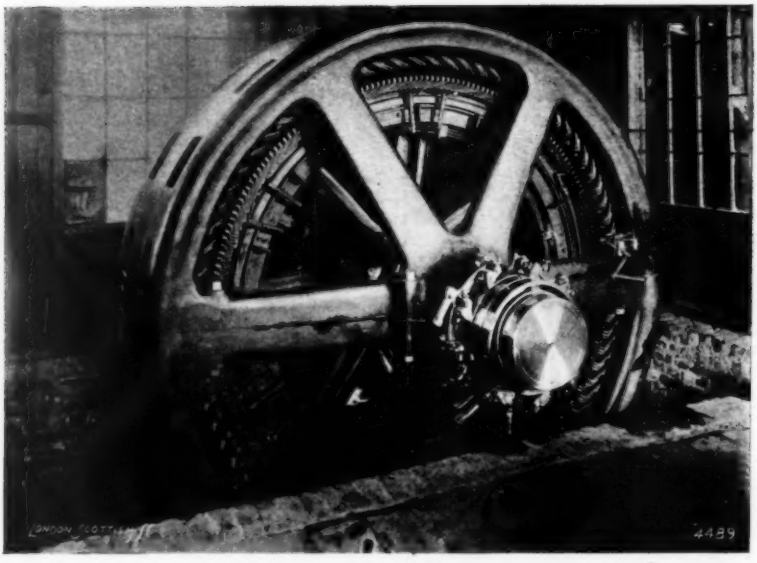


FIG. 5.—450-H.P. MOTOR OPERATING FINISHING MILL TRAIN.

5 and 20 tons capacity, and various others, from 5 to 30 tons capacity, are distributed through the works. Westinghouse crane-type induction motors are used throughout; these motors have a short-circuited "squirrel cage" rotor winding, with no outside connections: they are designed to have a very powerful starting torque. Very high speeds have been adopted for the cranes, the travelling speeds ranging up to 330 ft. per minute, and the lifting speeds to 50 ft. per minute. This elaborate crane system ensures the rapid and convenient handling of heavy work.

The smaller tools in the various shops are driven by belting from short jack-shafts actuated by Westinghouse type "C" motors. These are similar to the crane motors described above, with a more moderate starting torque; they are very simple in construction and thoroughly reliable, and being very hardy they are not damaged even by very heavy and prolonged overloads. They can be fixed in almost any position or roof, walls or floor, require no starting rheostats, and no attention beyond the occasional oiling of the bearings. An enormous number of these motors has been supplied by the Westinghouse Companies in Great Britain, the Continent and America, and there is no case on record where they have not worked satisfactorily. The larger machines, such as the Wellman furnace charger (see plate), are operated individually by one or more motors. Among the principal machines thus driven at present are a sliding platform, various pumps, including the pump of the central condenser station, furnace ventilators, and sand crushers. Two 40-h.p. motors operate the tables at the rolls, and two 60-h.p. motors operate the shearers.

Enough has been said to indicate that the equipment of these works, which has been designed by Westinghouse engineers on the most modern principles, presents features of peculiar interest both to the electrical and mechanical engineer. The photographs with which this article is illustrated give a capital idea of the general appearance and arrangement of the plant.

The Hult Rotary Steam Engine.

WHILE in recent years a remarkable development has taken place in that form of rotary engine which utilizes the velocity of steam, viz., the steam turbine, yet the efforts of those inventors who have attempted to construct rotary engines using the pressure of steam by means of pistons revolving inside stationary cylinders, or with other similar arrangements, have met with very little success, because either the friction has proved excessive or the leakage of steam has been considerable.

Bearing in mind that this lack of success has been due to the fact that the difficulties encountered have been only mechanical, and that there is no question whatever of involving the theoretical possibility of such a prime mover, it is, perhaps, not too much to assume that the satisfactory solution of the problem is only a matter of time and patience. However that may be, an important step in the right direction has been made by the inventors of the Hult engine, who have succeeded in perfecting a machine to which advantages belonging to no other system, including the reciprocating turbine types, would appear to attach. Starting from the fact that hitherto no rotary engine using the *pressure* of steam inside a fixed cylinder has yet been made which is sufficiently economical, the Hult inventors made the cylinder participate in the rotary motion of the piston, thus substituting rolling friction for sliding friction, which latter has hitherto been one of the chief efficiency losses in engines of the rotary type.

How far the adoption of the idea of causing the cylinder to rotate with the piston, which constitutes the principal novelty of the invention, has been productive of an economically working engine, let the following table, supplied by the makers, show :—

Hult Non-condensing Rotary Single-Cylinder Engine.

B.H.P. at 142 lbs. Pressure.	Steam per B.H.P.		Number of Revolutions per minute.	Weight of Engine complete.
	At 100 lbs. per sq.-in.	At 142 lbs. per sq.-in.		
	lbs.	lbs.		cwts.
8	...	...	1,500	1¼
12	40	35	1,300	4½
20	37	32	1,250	6
40	34	31	1,000	12
60	32	29½	850	17½
80	32	28	700	23
120	30	27½	550	38
200	29	27	500	52

On a six-hours' run made in this country by a Hult engine, a dynamo guaranteed for an output of 34 kilo-watts, the total weight of water consumed was 10,176 lbs., with an average pressure of 115 lbs. per square inch, and 611 revolutions per minute. The steam consumption, with exhaust into the open air, and no means being used for drying the steam, worked out to 28·5 lbs. per i.h.p.

On comparing these figures with the steam consumption of many makes of reciprocating engines, they will be found to be very satisfactory, particularly as regards the smaller sizes.

The general principle of the working of the engine will be understood by reference to the schematic Figs. 1 and 2. The piston *F* is shrunk on the main shaft *A* in a position within and eccentric to the cylinder *C*, the steam admission being through the passage *H*, and the exhaust taking place through *I*.

G is a shutter sliding in a recess cut in the piston : its movement outward is caused by centrifugal force, and it makes with the cylinder wall a perfectly steam-tight joint. At the point of contact with the cylinder wall and piston, viz., the

position indicated by the centre line in Fig. 2, the shutter is sunk completely in the piston and, as both revolve, the shutter begins to emerge, reaching the maximum distance separating the cylinder wall and piston when it has assumed a vertical position at the point *C* on the centre line (Fig. 2).

The steam from the boiler enters through the hollow shaft and inlet passage *H*, to the space enclosed between the point of contact of piston and cylinder and the shutter *G* (indicated in Fig. 2 by the stippled portion), and the pressure thus acting on the shutter, which has the same length as the piston, causes the latter to revolve. As the piston is in contact with the cylinder, setting up a pressure between them, the latter also revolves with the piston and in the same direction.

It will be seen that as the cylinder is eccentric to the main shaft the steam space between the piston, cylinder, and shutter gradually increases as the revolution continues, and when the piston reaches a certain angle the admission is cut off automatically by a valve placed inside, or at one end of the hollow shaft. Expansion then takes place, until the pressure becomes low enough, say, for example, when two-thirds of a revolution has been completed, when the rotary motion of the piston, which is eccentric to the cylinder, uncovers the exhaust openings. Thus, in the cylinder itself there is no gear for the steam admission and exhaust.

The shaft with the piston runs on the roller bearings *B K*, the cylinder running on those shown at *E L*. Both piston and cylinder have the same circular velocity, but in consequence of their eccentricity the angular velocity of the piston is slightly higher. By this arrangement the sliding friction which exists in reciprocating and earlier rotary engines is almost entirely avoided.

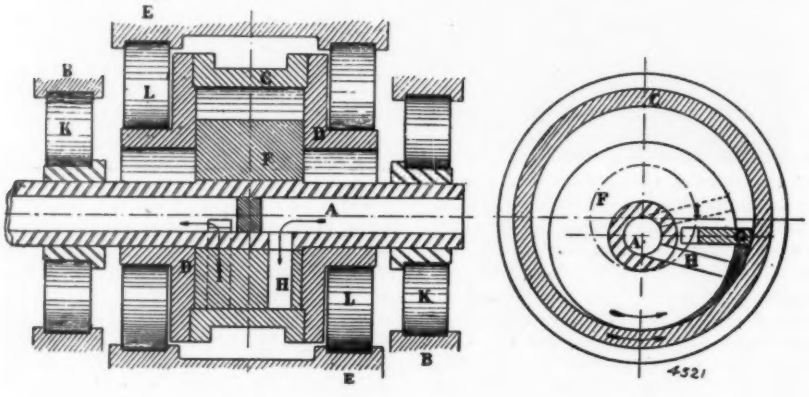


FIG. 1. FIG. 2.

LONGITUDINAL AND TRANSVERSE SECTIONS THROUGH A SIMPLE HULT ENGINE.

An end view of the cylinder bearings is shown in the photographic reproduction, Fig. 3, and those supporting the shaft and piston in Fig. 4; they are all kept at their relative distances by guide-rollers, as shown. The rollers run on racers fixed in the frame and frame-covers respectively.

When easing the nuts holding the frame-covers, the adjusting screws on the top of the frame can press the piston and cylinder together, at the line of contact, so as to ensure that the cylinder follows the rotation of the piston while keeping the line of contact steam-tight.

Some recent modifications have been effected, improving the power and efficiency of the engine. Figs. 5—7 illustrate the details of construction, Figs. 5, 6, showing an engine of the two-shutter type, and Fig. 7 one of the three-shutter type.

Taking the two-shutter type first (Figs. 5, 6), steam enters the box 30, passes along the tube 32, and reaches the cylinder through the ports 9 and 10 every time one of them has passed the line of contact between the cylinder and piston, which is situated at the lower portion of the centre-line of both cylinder and piston.

The steam acts on the sliding-shutter 8, which at the line of contact is pressed home in the piston exactly as described in the scheme; admission, expansion, and exhaust taking place during the period of one revolution.

The steam-distributing apparatus is placed in the hollow main shaft 13, and consists of an inner fixed tube 32, an outer revolving tube 33, and a rod 35, connecting the lining tube 33 with the admission valve 36, which is perforated by a number of slots through which the steam can enter into the fixed tube 32. The tube 33, the rod 35, and the valve 36 thus participate in the rotary motion of the piston. The revolving tube 33 is pierced with

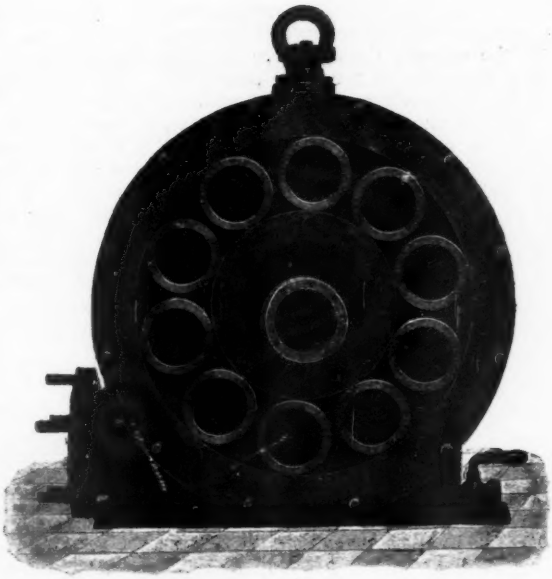


FIG. 3.—DETAILS OF CYLINDER BEARINGS.

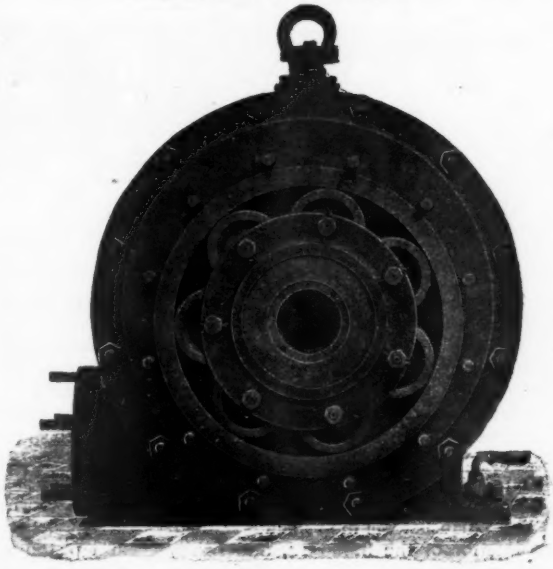


FIG. 4.—SHOWING THE SHAFT AND PISTON BEARING ARRANGEMENTS.

slots opposite to the steam ports 9 and 10, so that steam at full pressure is admitted into the cylinder through these passages every time one of the slots passes the corresponding orifice in the fixed tube 32.

The governor, placed in the box 37, is of the centrifugal type; its disc 38, fixed to the steam admission valve 36, at the end of the rod 35, which is bevelled so as to allow the passage of steam, revolves at the same speed as the piston. The weights 39, equilibrated by a spring, are connected by levers 42 with the plate 41, connected with the governor-valve 34, which has openings corresponding to those of the admission-valve. The weights, when separated by centrifugal force, cause a pull on the levers and give to the governor-valve an additional rotary motion.

After expansion has taken place the steam exhausts through the passages 11, and the orifices 12, on the faces of the piston. The latter are also clearly seen in Fig. 8, as are the two shutters.

The exhaust-steam then spreads through the interior of the frame 14, and finally issues through the exhaust-pipe 46 to the condenser or into the open air.

The arrangement of roller-bearings, on which run the cylinder and shaft, are practically the same as in the case of the single-shutter scheme. It should be mentioned, however, that a steam-tight fit between the ends of the piston and cylinder is secured by means of a disc 4, which is placed at the left end of the piston. Its position may be modified by the adjustment screws 6 pressing upon the wedges 5; these screws being reached by the removal of the screw cover 19.

The three-shutter engine, of which a cross-section is shown in Fig. 7, is in many respects similar to the two-shutter engine, except that there are three shutters, with three admissions of steam, the cycle of admission, expansion, and exhaust for each shutter being completed during one revolution. The power is thereby increased, and is better distributed than in the two-shutter engine, while the condensation of steam in the cylinder is reduced to a minimum by the walls being maintained at a more constant temperature.

The action is as follows:—The cylinder and piston revolving in an anti-clockwise direction, the shutter 8*a*, immediately after leaving the point of contact, will be acted

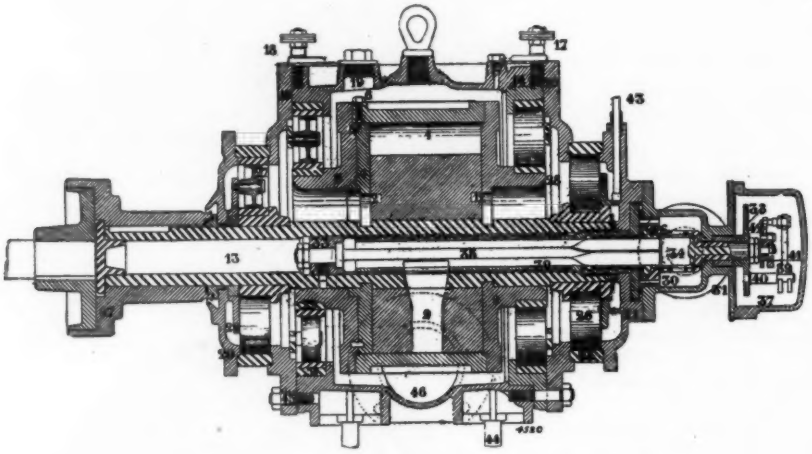


FIG. 5.—LONGITUDINAL SECTION OF LATEST TYPE ROTARY ENGINE.

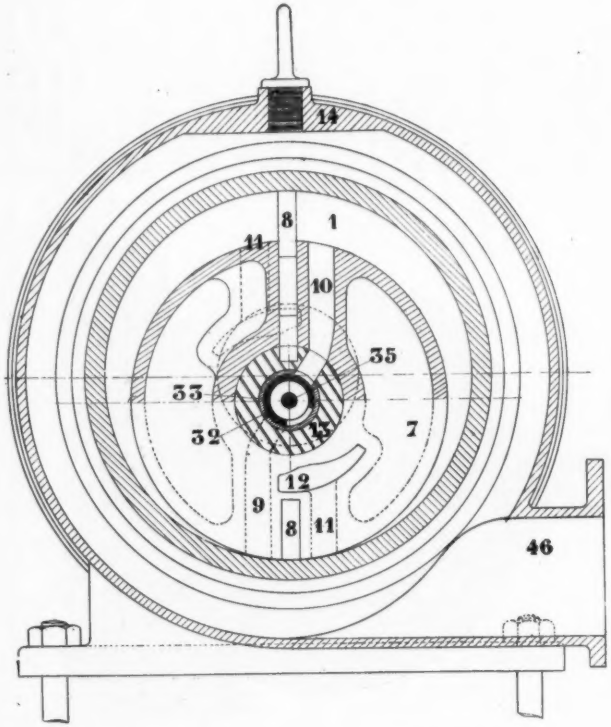


FIG. 6.—TRANSVERSE SECTION THROUGH A TWO-SHUTTER HULT ENGINE.

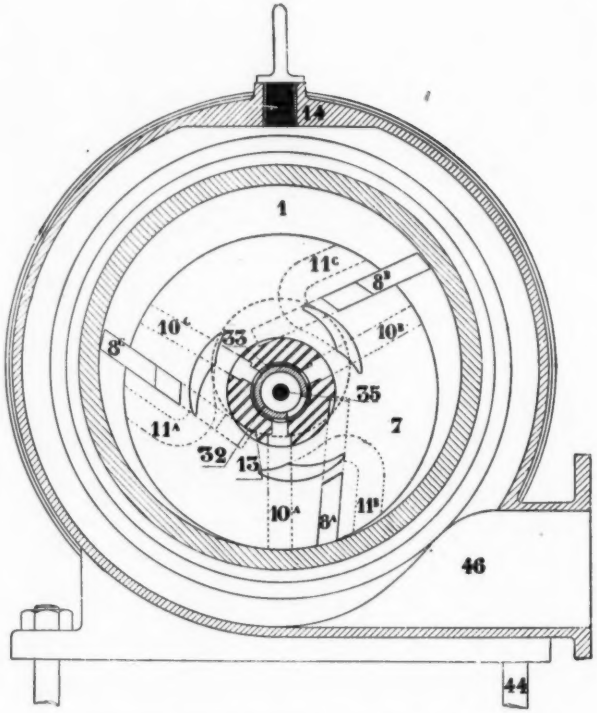


FIG. 7.—TRANSVERSE SECTION THROUGH A THREE-SHUTTER HULT ENGINE.

upon by freshly admitted steam, admission continuing until the shutter 8*a* occupies the position occupied in the figure by 8B. At this point cut-off takes place, expansion commences and continues until the shutter 8*a* reaches the position occupied in the figure by 8*c*, when the exhaust passage is opened. Before this is quite completed fresh steam is again admitted.

In this cycle, therefore, when exhaust commences of the steam that has been acting upon the shutter, 8*c*, the shutter behind it, 8B, is being driven by expansion, and the third, 8*a*, is just passing the admission point and is being acted upon by steam at full pressure. The admission ports are shown at 10 (Fig. 7), and the exhaust passage at 11 ; the steam admitted for one shutter, through the passage 10*a*, acts upon the shutter 8*a*, and is exhausted through the passage 11*a*, and in the same way 10B, 8B, and 11B act together. The roller-bearings, lubrication, governor, etc., remain the same as for the two-shutter engine.

The speed at which these engines run lends itself admirably for electric driving. Varying from 1,500 revolutions per minute in the smallest sizes to 400 for the largest, direct coupling becomes a convenient method, as intermediate gear for raising or lowering the speed can be dispensed with.

The engine occupies a very small space: the 5 b.h.p. engine (at 150 lbs. pressure) is 18 ins. long, 10 ins. high, and 9 ins. wide ; the 250-b.h.p. engine (at same pressure) is 6 ft. long, 3 ft. 4 ins. high, and 3 ft. wide. A complete plant of 15-b.h.p. engine, direct-coupled to a dynamo on the same base-plate, occupies a space 3 ft. long by 20 ins. wide, the height of the engines being generally the same as that of the dynamos.

The weight varies from $1\frac{1}{4}$ cwt. for 5 b.h.p. to 52 cwts. for 250-b.h.p., and for complete lighting plant of engine direct coupled to dynamo on same base-plate, the weight for 5 b.h.p. is 5 cwts., and for 150 b.h.p., $4\frac{3}{4}$ tons.

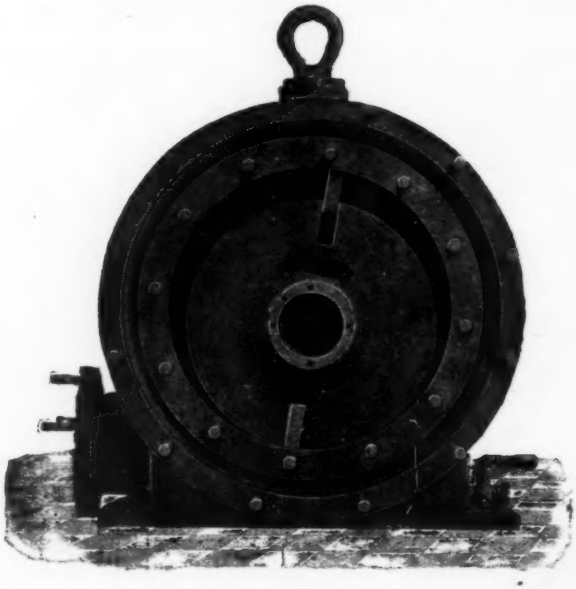


FIG. 8.—END VIEW SHOWING SHUTTERS, EXHAUST ORIFICES, PISTON, AND CYLINDER.

An important point is that, as in the case of the steam turbine, the rotary motion causes the engines to work exceptionally silently and smoothly and without shocks. There is no variable inertia of moving parts to affect the stand or foundation ; and in a recent test made in this country a 34-kilowatt set direct coupled on the same base-plate, and standing on a sheet of cork without being bolted down, ran for six hours without any appreciable vibration.

The description given above of stationary Hult engines also applies to marine engines, except in the arrangements for the distribution of steam, which in the latter are

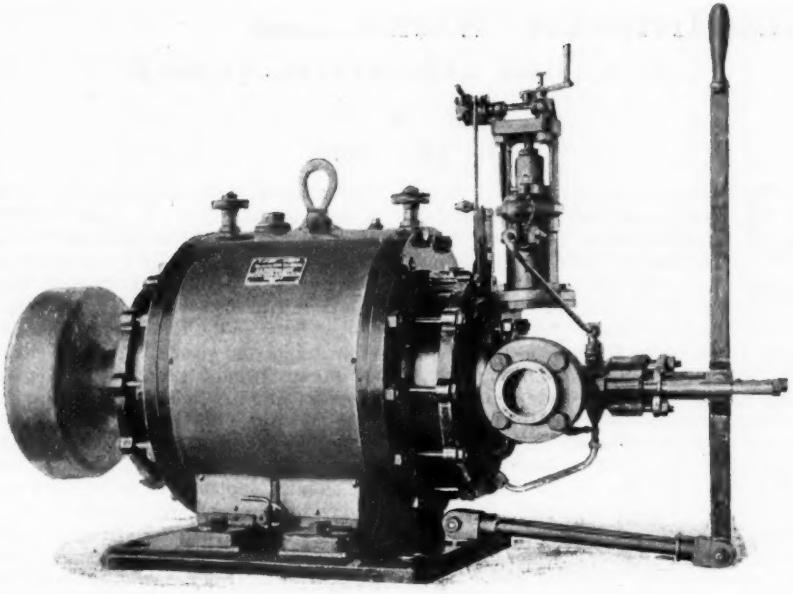


FIG. 9.—MARINE TYPE REVERSING ENGINE.

modified to suit the requirements for reversing and variation of speed. Reversing is obtained by moving lengthwise the distributing tube for admitting the steam on one side or the other of the sliding shutters.

Fig. 9 is an exterior view of a reversible type marine engine; the engine shaft being direct coupled to the screw shaft without cranks or fly-wheel.

In concluding the notice of this very interesting engine, mention may be made of the fact that it is now being actually made in sizes up to 250 b.h.p. in Stockholm, Kiel, Nancy and St. Petersburg. That there should be a future for it in this country cannot be doubted, and we shall watch its development here with keen interest.

Nile Irrigation Works.

By W. NOBLE TWELVETREES, M.I.Mech.E.

I.—The Delta.

ORIGINALLY pursuing its course through an arid and practically rainless desert, the river Nile has brought down from distant regions all the soil that now constitutes the cultivable land of Egypt. The soil so deposited averages from 33 ft. to 38 ft. in depth, and near the apex of the Delta it is fully 50 ft. deep, the bottom in places being below the level of the sea. Formerly the inundation caused by the overflow of the river converted the Nile Valley and Lower Egypt into a huge lake, but works for regulation of the flood were carried out long ago by early engineers. These works afterwards suffered neglect for hundreds of years, until the engineering control of the Nile was again taken seriously in hand at the beginning of last century. The latter part of the century witnessed the execution of various works of the utmost importance, as well as the inauguration of those still greater undertakings at Aswân and Asyût, which were formally dedicated to the public service in December last by H.R.H. the Duke of Connaught. The Aswân dam and the Asyût barrage may justly be categorised with the highest achievements of the engineer in any land or age; but it must not be forgotten that the function of each is strictly limited, and that those works, stupendous though they be, do not by any means complete the task of the irrigation engineer in Egypt. The complete regulation of the Nile is still required on a scale that shall give to the whole of Egypt and the newly added or, more correctly, lately restored provinces abundant supplies of water at all times, without possibility of failure even in the most unfavourable years.

For the moment we are merely concerned with those parts of Egypt and the Nile which lie to the north of Cairo. The triangular area known as the Delta is an alluvial plain of great fertility, measuring about 100 miles from north to south, and approximately 150 miles along the shores of the Mediterranean Sea. Lower Egypt consists of (1) the Delta proper, between the Rosetta and Damietta branches of the river; (2) the Behêreh, to the west; and (3) the eastern districts, extending to the Suez Canal. The area of land nominally under cultivation is about 3,500,000 acres, but much of this is only partially developed, partly because the summer supply of water is insufficient, and partly because its reclamation is not yet completed. It may be seen from any good map of Lower Egypt that large tracts of land are more or less completely covered by water all along the margin of the sea. All of these will no doubt be reclaimed in course of time; but the great essentials are money, and water for irrigation. The most important of these tracts is Lake Menzaleh, covering an area of over 600,000 acres, once one of the most fertile regions in Egypt, and intersected by three branches of the river, which have long since disappeared. Lake Borillos is another waste region, having a summer area of 165,000 acres which was formerly increased to nearly 500,000 acres in flood time. A third area of considerable extent is Lake Edku adjoining the site of Lake Abukir, now reclaimed. Lake Mareotis is one more area which might be recovered, at least in part. For centuries it has existed as an inland harbour, lying 8 ft. below sea level, but the land around it was extremely fertile. Owing to the cutting of the neck of land, separating the lake from the sea, about a hundred years ago, an extensive area was laid under water, and it is estimated that fully 100,000 acres of cultivable land await

reclamation at the present time. Further, it will be seen from the map that large tracts of swampy ground exist which are dry in summer, and in 1887 it was stated by Mr. Willcocks, now Sir William Willcocks, K.C.M.G., the well-known engineer who was formerly Director-General of Reservoirs, that in the province of Gharbîyeh alone some 300,000 acres then awaited reclamation.

So far as concerns the river, it is only necessary at this point to say that its lowest level is reached about the middle of June, after which the annual rise commences, and attains its maximum at the beginning of October. The time of high Nile was formerly the occasion of an annual festival, when an earthen dam closing the canal of Cairo was ceremoniously cut, and the process of irrigation was inaugurated. Flood irrigation, affording only one crop a year, was then universal in Lower Egypt, as it had existed with little or no change for fully 7,000 years. The splendid works of early engineers are still in evidence, showing the skill and intelligence brought to bear on the regulation of the Nile in olden times. Through neglect of ancient dykes and systems of regulation, notably during the Byzantine supremacy and under the evil misrule of the Mamelukes, much harm was done. The sea overflowed low-lying lands, forming the swampy lakes, to which reference has already been made, and the produce of the land was reduced to less than one-half of that previously realised. Then followed a period when the culpable neglect of former times began to be repaired. Mehemet Ali, not an entirely admirable man, proved to be on the whole a wise and a strong ruler, who did much for Egyptian agriculture. The system of perennial irrigation in Lower Egypt, permitting the growth of sugar and cotton, and affording three crops a year, was really inaugurated by him, his first attempt in this direction being the construction of a system of irrigation canals.

Some of the canals were deep, for the conveyance of water from the river when at its lowest level, and others were shallow, for use during flood time. The deep canals, or Nili, could only be used in the summer-time by the aid of mechanical appliances for raising the water, thus necessitating a method of irrigation that left the fertilising mud to choke up the canals instead of delivering it upon the land. The shallow canals, or Sêfi, were dry in summer-time, and could only be used during the prevalence of the flood. Much trouble has been due to the deep canals, which for small tracts of land were about 10 ft. wide and 20 ft. deep. Regulators had to be built at frequent intervals, to bring the water up to the required level. Heavy deposits of silt were consequently caused in the canals, and their removal by forced labour involved great hardship on the people, besides affecting the general prosperity of the country by withdrawing men from the work of agriculture. Further, in spite of various regulating devices, the canals were so disproportionately capacious that, during flood time, they carried excessive quantities of water to low-lying lands in the northern districts of the Delta. The result was to fill up irrigation canals, escapes, and drainage cuts, in such a way that their proper functions could not be exercised. Hence the country became converted into a number of islands surrounded with water at comparatively high level, and not only was salt efflorescence induced, but considerable areas were maintained in a swampy condition.

In the time of Mehemet Ali the appliances available for raising water from the canals were of the most unregenerate nature, and similar contrivances are still employed in different parts of the country to the present day. The most familiar is the "Shâdûf," consisting of a bucket or earthen vessel hung from one end of a counter-weighted pole, which is balanced on supports of primitive construction. Sometimes a series of shâdûfs is employed, arranged one above another, as illustrated in Fig. 1, so as to increase the total lift.

The "Sâkiyeh," another water-lifting apparatus, consists of a large wheel, round which is hung an endless rope band furnished with wooden scoops or earthen vessels. The wheel is driven from a particularly crude form of gear actuated by oxen, buffaloes, camels or asses. Fig. 2 will enable the reader to form a fairly

accurate idea of this interesting contrivance.

The "Tâbût" is a lighter form of water-wheel, used chiefly in the Lower Delta, and in places where the water level is fairly constant. Water is also raised by buckets, slung on a rope between two labourers, and by the aid of archimedean screws and centrifugal pumps. It appears to have occurred to Mehemet Ali that the labour involved in the lifting of water for summer irrigation was somewhat excessive, and he then conceived the great idea of constructing a barrage near Cairo, with the object of holding the water up to such a level that it would be able to run straight upon the land.

FIG. 1.—THE SHÂDÛF (AS USED IN SERIES).

The design of this work was entrusted to Mougel Bey, an able French engineer in the Government service. A considerable diversity of opinion exists as to the exact year in which the Cairo barrage was commenced. As a matter of fact, we believe it was begun in some sort of fashion in the year 1835, but so many difficulties were experienced by Mougel Bey that there is some justification for the statement sometimes made that the barrage was not commenced until 1847. The mean difference between the highest and lowest levels of the Nile at Cairo is about 25 ft., and the intention was that the barrage should hold up water some 15 ft. during the summer-time. By reference to the map, it will be seen that the site chosen for the barrage was about 15 miles below Cairo, at the point where the river divides into two main channels. Although generally spoken of as "The Barrage," the work really consists of two barrages or "regulators," one across the Rosetta channel, and the other across the Damietta channel. The first of these structures is 1,437 ft. long, and the second 1,709 ft. long, while

between the two is a revetment wall 3280 ft. in length, in the middle of which is the head of the Delta main irrigation canal, known as the Menûfiyeh Canal. In order to distinguish the structure from later works of the same class, it is now designated the "Delta Barrage."

Fig. 3 contains a longitudinal section, plan, and cross-section of the Rosetta branch barrage as it appeared in 1884. The following is a description of the structure as it then was. The platform consisted of concrete covered with brick and stone masonry; it was 151 ft. wide by 11 ft. 6 ins. deep, with a rubble "talus" of varying width and depth. The platform, flush with the river bed, rested on mud and sand, and as the left-hand portion was over the original deep channel of the river, it was necessary to form a foundation of rubble, which was made about 30 ft. deep by 394 ft. wide, at the deepest part. Upon the platform was raised a brick superstructure in the Norman castellated style, really constituting a regulating bridge, with two locks, 213·2 ft. long, one at each end, 39·4 ft. and 49·2 ft. wide respectively. There were 61 openings in this barrage, each 16·4 ft. wide; 57 of the piers were 6·6 ft. wide, and the remaining three 11·6 ft. wide; the height of the piers was 30·2 ft., and the breadth of the bridge was 52·5 ft. Forty-seven of the openings were closed by iron gates 19·7 ft. high, and the others by vertical timber piles with horizontal oak beams. Neither the gates nor the piles reached to the platform, but rested upon gratings 1 ft. high. Fig. 4 is a typical view of the Rosetta barrage from the upstream side, as it now appears.

FIG. 2.—THE SÂKIYEH (WITH OX-GEAR).

The Damietta branch barrage was of similar construction, but with 71 openings, which were not furnished with gates, and one of the locks was also unprovided with gates. At the time when the barrage was designed, the Damietta branch was wider than the other channel, hence the

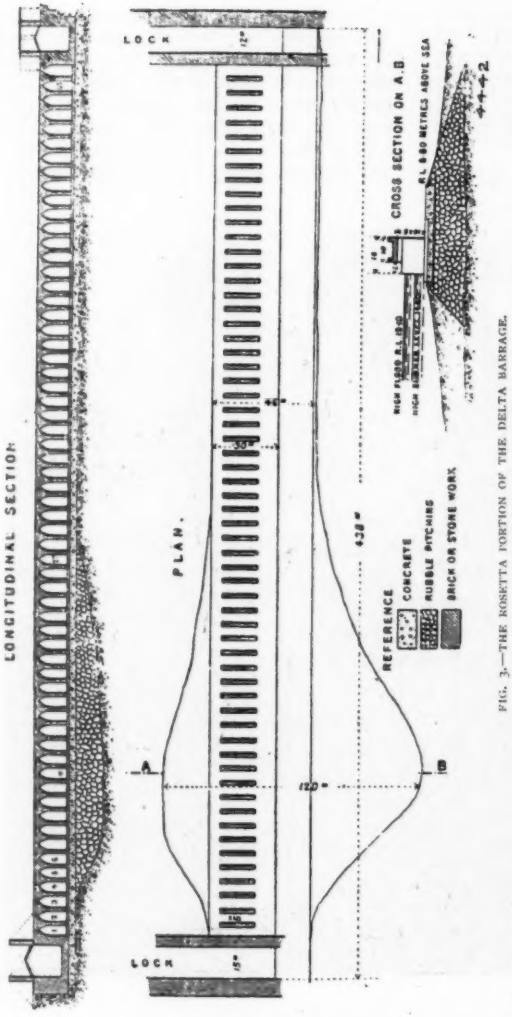


FIG. 3.—THE ROSETTA PORTION OF THE DELTA BARRAGE.

greater number of openings. In 1877, when Sir Charles Hartley, K.C.M.G., inspected the barrage, he was convinced that the natural tendency of the Nile was to direct itself more and more to the west, and he expressed the belief that if the river were left much longer without control, the Damietta barrage might be left high and dry. This condition of things sufficiently accounts for the fact that at the present day the Rosetta barrage has 20 openings too few, while the Damietta barrage has 20 openings too many.

This description will serve to give a general and approximate idea of the work commenced, but never really finished, by Mougel Bey. In justice to the memory of that able engineer, it must be said that he had to encounter many unnecessary difficulties due to scarcity of suitable materials, deficiency of proper appliances and skilled labour, and, above all, to the irrational caprice of an Oriental despot. It is commonly asserted that the barrage was completed in the year 1862, but the statement is not strictly accurate. That was the year when the work was left uncompleted, and it was not then finished to the extent indicated by our description of its condition in 1884. During the years immediately following 1862, very little use could be made of the unfinished barrage, because the foundations were known to be faulty. In 1867, the floor of the Rosetta portion settled some four or five inches, causing vertical and horizontal deflection of the structure, clearly perceptible to the eye. Altogether, ten of the openings were then damaged, and for their protection a cofferdam of timber filled with stone was built on the platform. As the Damietta portion could not be closed for want of gates, the advantage derivable from the partial closing of the Rosetta barrage was very slight. In fact, the upstream water level could only be raised by 1·6 ft. when the barrage was under a head of 5·6 ft. of water. Things remained in this unsatisfactory condition for some years, and in 1876 the late Sir John Fowler examined and

reported upon the structure, recommending that two "movable" weirs should be built, one on the down-stream side of each barrage, so as to hold up 10 ft. of water, and as it had been shown that over 5 ft. could be held up by the barrage itself, he proposed that in this manner the original intention of the designer might be realised. Sir John Fowler believed that the foundations of the barrage could not be effectually repaired, and his proposed weirs were to be of great depth, so as to remove all anxiety on the score of infiltration, either through or below the masonry of the then existing work. A report was made at about the same time by M. Gatget, a distinguished engineer representing the Fives-Lille Company in Egypt, and his project was to build a strengthening wall, founded at a great depth, about 44 yds. above the old works. He suggested that sluices should be placed on this new structure to hold up 19 ft. of water, and that the space between the old and the new works should be filled up by widening the existing platforms. A later report by Sir Charles Hartley, K.C.M.G., spoke favourably of both the above-mentioned proposals, but bearing in mind the supposed danger of percolation underneath the foundations, Sir Charles thought the best means of rendering less permeable the substratum of fine sand composing the bed of the Nile below the barrage, would be the construction upon it of a massive wall of great weight, as proposed by Sir John Fowler. No result followed the presentation of these reports, which, no doubt, were carefully put away in the Egyptian equivalent for the pigeon-holes used in this country for the burial of Reports made by Royal Commissions. In one way it was perhaps fortunate that the recommendations were not adopted, for they were all based upon a misconception as to the precise condition of the foundations. This remarkable

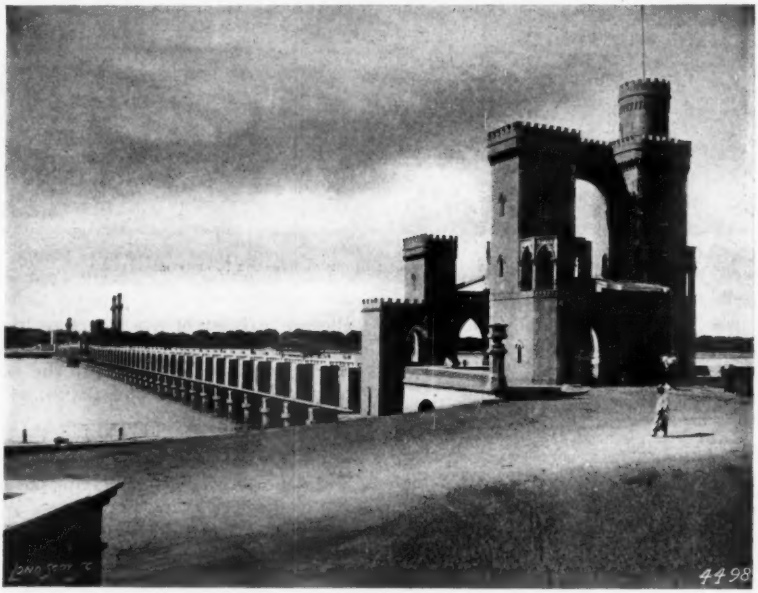


FIG. 4.—VIEW OF THE ROSETTA PORTION OF THE DELTA BARRAGE.

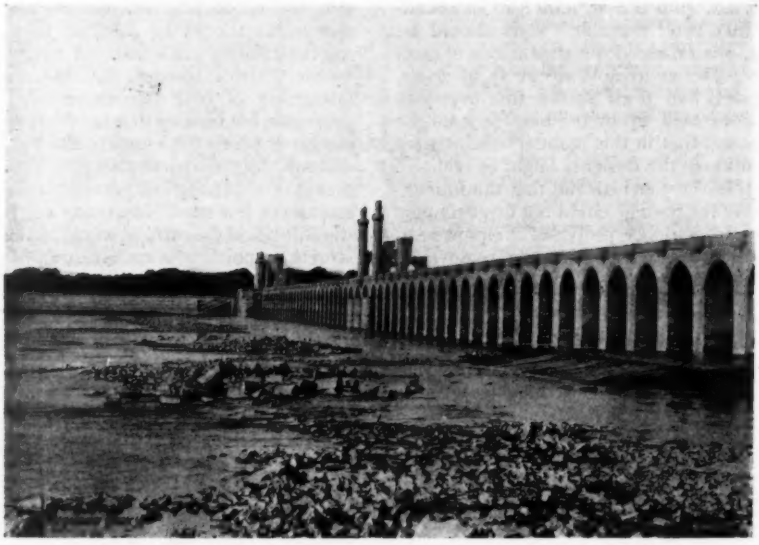


FIG. 5.—VIEW OF ROSETTA PORTION OF THE DELTA BARRAGE (DOWNSTREAM SIDE).

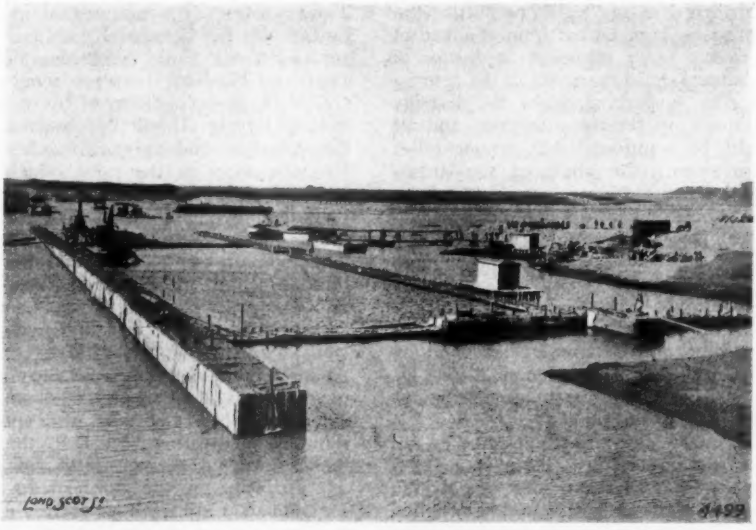
fact was first made generally known by Mr. (now Sir William) Willcocks in the following words :—

"The severe action below the barrage when a gate was lowered to its full extent was found to be due to iron gratings, or 'windows,' in the foundation, and not, as it had been supposed, to a honeycombed foundation. This fact was apparently unknown to the writers of the Reports on the Barrages. Indeed, it ought to have been evident that if all that action was due to fissures in the foundations, the barrage would have been swept away years ago."

The meaning of this startling statement was that practically all the water then escaping through the barrage actually found its way through open gratings, and not through fissures in the concrete, as had been formerly assumed. In commenting upon the novel view thus presented, Sir Charles Hartley said that he heard of these *open* gratings for the first time. Their existence had never been mentioned by M. Gatget or the Minister of Public Works when those gentlemen accompanied him to the barrage ; and in all his communications with Sir John Fowler it was taken for granted that the alleged inability of the structure to withstand uninjured a greater head of water than 6·56 ft. was solely due to the porous nature and insufficient depth of the foundations.

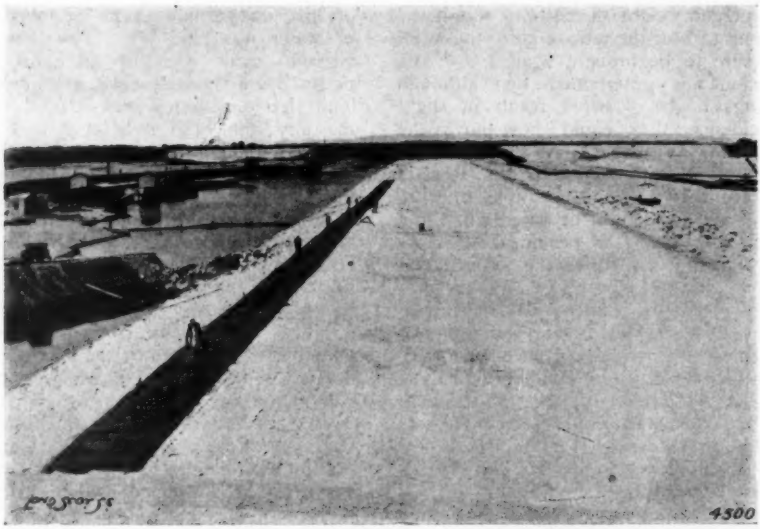
Parts of the foundations were undoubtedly defective in the Rosetta barrage, and some percolation was taking place, but not to the serious and alarming extent that has been popularly believed, while, as for the Damietta barrage, absolutely no records were available at the time of which we are now speaking. On his appointment as Under-Secretary of State for Public Works in 1884, Sir Colin Scott-Moncrieff, K.C.M.G. (then Colonel Scott-Moncrieff, R.E.) accepted the more favourable view as to the condition of the barrage foundations, courageously setting aside the pessimistic predictions of his predecessors, and disregarding the feelings of distrust generally entertained as to the stability of the structure, he determined to undertake in earnest its thorough restoration. Treating the barrage as an entirely unsound work, relying upon friction alone for stability, it was decided that the

submerged weight of masonry should be caused to bear the ratio of 50 to the water pressure to be brought against it. The opinion was entertained that although springs might possibly result in slight subsidence, they could not move the barrage as a whole. At that time the proposal was to so repair the Rosetta barrage that it should be able to withstand a head of 10 ft. of water, equal to a pressure of 3,125 lbs. per lineal foot. As the submerged weight of the platform was 103,983 lbs. per lineal foot, the ratio was then only as 33 is to 1. In order to increase this ratio to the desired extent it was necessary to make the talus 131 ft. wide by 10 ft. deep, thereby adding a weight of 51,668 lbs. per lineal foot. During 1884 and 1886 the barrage was under the charge of the present Sir William Willcocks, with Mr. Arnold H. Perry as Resident Engineer, and by January 1884 about one-third of the additions to the talus was completed. The sluice openings were then closed and the offending gratings blocked up; but owing to the incomplete state of the talus, no more than 7·2 ft. of water was held up. The Damietta barrage next received attention, the talus being considerably strengthened. The left-hand lock was closed by a masonry dam, the right-hand lock was repaired, all the openings were furnished with vertical piles and oak horizontals, so that they might be closed to hold up 3·3 ft. of water. Up to this point the water level above the barrage as a whole was maintained 3·3 ft. higher than it would have been under the previously existing state of things. A similar programme was followed in 1885; large quantities of stone were added to the talus, and a temporary stone dam was raised upon it, so that the barrage should hold up 6·7 ft., and the dam 3·3 ft., making 10 ft. of water held up altogether by the Rosetta portion. The Damietta portion was enabled to hold up 5·6 ft. of water. The temporary dam on the talus was afterwards removed by the transference of the material to the talus itself. In 1886, Mr. Perry, then in charge of the barrage, continued the work of repair, and the floors of several openings



[*From a photograph by Sir R. Hanbury Brown, K.C.M.G*

FIG. 6.—ROSETTA BRANCH WEIR, LOOKING WEST, IN MARCH, 1900.



[*From a photograph by Sir R. Hanbury Brown, K.C.M.G.*

FIG. 7.—ROSETTA BRANCH WEIR, IN JULY, 1900.

were exposed and made watertight. This operation was aided by the formation of an earthen dam, or "sadd" permitting the water to be pumped out from the bed of the river. Fig. 5 represents a portion of the barrage during progress of the restoration. In succeeding years the barrage continued to receive attention, and it should be mentioned that, among other improvements, the whole of the sluices were fitted with the ingenious gates of the type associated with the name of the late Mr. F. G. M. Stoney, M.Inst.C.E., and which have been since adopted in connection with the irrigation works in Upper Egypt. By the year 1890, the work designed by Mougel Bey was practically completed, an achievement by which Sir Colin Scott-Moncrieff and his staff justly earned the warm congratulations which were expressed at the time.

We must now direct attention to an extremely important work in connection with the Delta Barrage, consisting of the new weirs on the downstream side, designed by Sir Robert Hanbury Brown, K.C.M.G. (then Major Brown, R.E.), Inspector-General of Irrigation in Lower Egypt. Their construction was approved in 1897 by Sir W. E. Garstin, K.C.M.G., who succeeded Sir Colin Scott-Moncrieff in 1892, and has lately been promoted to be G.C.M.G., in recognition of his valuable work in Egypt. It will be observed that the principle underlying the scheme of the new weirs is the same which was involved in the proposal made many years ago by Sir John Fowler, but the system of construction was distinctly novel. The method adopted was to form continuous chains of solid masonry blocks under water by grouting stone which had been tipped from rafts into timber caissons. Both branches of the Nile were thus dammed by solid walls of masonry 23 ft. deep and 10 ft. wide, protected on each side by masses of clay 33 ft. wide and 6 ft. thick, pitched with rubble 8 ft. thick by 50 ft. wide on the up-stream side, and 150 ft. wide on the down-stream side. Figs. 6 and 7 are reproduced from photographs taken by Sir R. Hanbury Brown.

(To be continued.)

Some Notes on the Commercial Management of Electrical Tramways.

By T. W. SHEFFIELD, A.M.I.Mech.E., A.M.I.E.E.

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RECENT rapid developments, and the ever-increasing tendency to apply electricity as a motive power to tramway systems hitherto using horse traction, is, I trust, sufficient reason for this article, in which the endeavour will be made to point out the advantages that might accrue to municipalities and tramway companies if better attention were paid to the commercial management of their tramway systems.

Although it will probably be conceded that successfully organised tramways are playing a most important part in the business and social life of our cities and their suburbs, it may nevertheless be interesting to note the firstfruits of the labours of the Manchester Tramways Committee and those associated with it in the early stages, and the results realised on the first section running. This can easily be done by reviewing the estimates for the current year. Considering that the committee have only been working these trams since June, 1901, the figures are somewhat striking, and form a very good forecast of what is to come. It is anticipated that the traffic receipts up to March 31st, 1903, will reach £250,000, and that from other sources (including rental of tramways by the carriage company) this sum will be increased to £260,306, The estimated expenditure during the same period is put down at £206,052. This sum includes, among the heavier items, £29,375 for power, £85,850 for traffic expenses, £20,883 for general expenses, £18,200 repairs and maintenance, and £38,865 for interest on loans. After meeting the expenditure there will, it is believed, be an available surplus balance of £56,984, out of which it is proposed to contribute £30,000 to the city fund in relief of the rates, and transfer £26,984 to the reserve, renewals, and depreciation fund. Last year the estimated income was £113,830, and there was an available balance of £30,600, out of which £20,000 was paid in contribution to the city fund, and £10,600 transferred to the reserve, renewals, and depreciation fund. On capital account there will be, it is estimated, an outlay of £600,000, of which £120,600 is for land and buildings and £352,700 for cars and equipments. Last year an expenditure of £625,000 was anticipated on this account, and the approximate outlay was £381,976. Still better results may be expected when the 150 miles of tramways in Manchester and its suburbs are in operation, and the catering for the requirements of its large population is in full swing.

It is a healthy sign of the times to see corporation officials striving for success in the departments under their control, although it is important to bear in mind that this is not done at the expense of some other department. For instance, the tramway department should pay its own way, and all profits accruing should be devoted to cheapen the fares and extend the system. One of the main difficulties that municipal tramway undertakings have to labour under is the fact that until quite recently they were worked by private companies, whom the corporations unduly pressed in regard to the proportion of cost of the making and maintenance of streets. But this squeezing policy should not pervade the minds of members of a city council regarding one of its own departments, because, if persisted in, the finance of the concern is bound to be affected, and the many advantages of tramway extension and reduction of fares will be retarded, and the community will be the losers in consequence. My contention is that all departments of a corporation should assist

as much as possible in giving the tramway service an unrestricted and unprejudiced position in working out its own salvation. The tramways should act as a feeder to their own progress by way of their profits being used for the extension of their own system, and in order to obtain this most desired end, they ought to be handled with the greatest care. A remunerative tramway system will thus be ultimately developed, and become a source of revenue in the hands of the corporation, to be used in the interests and for the benefit of the community.

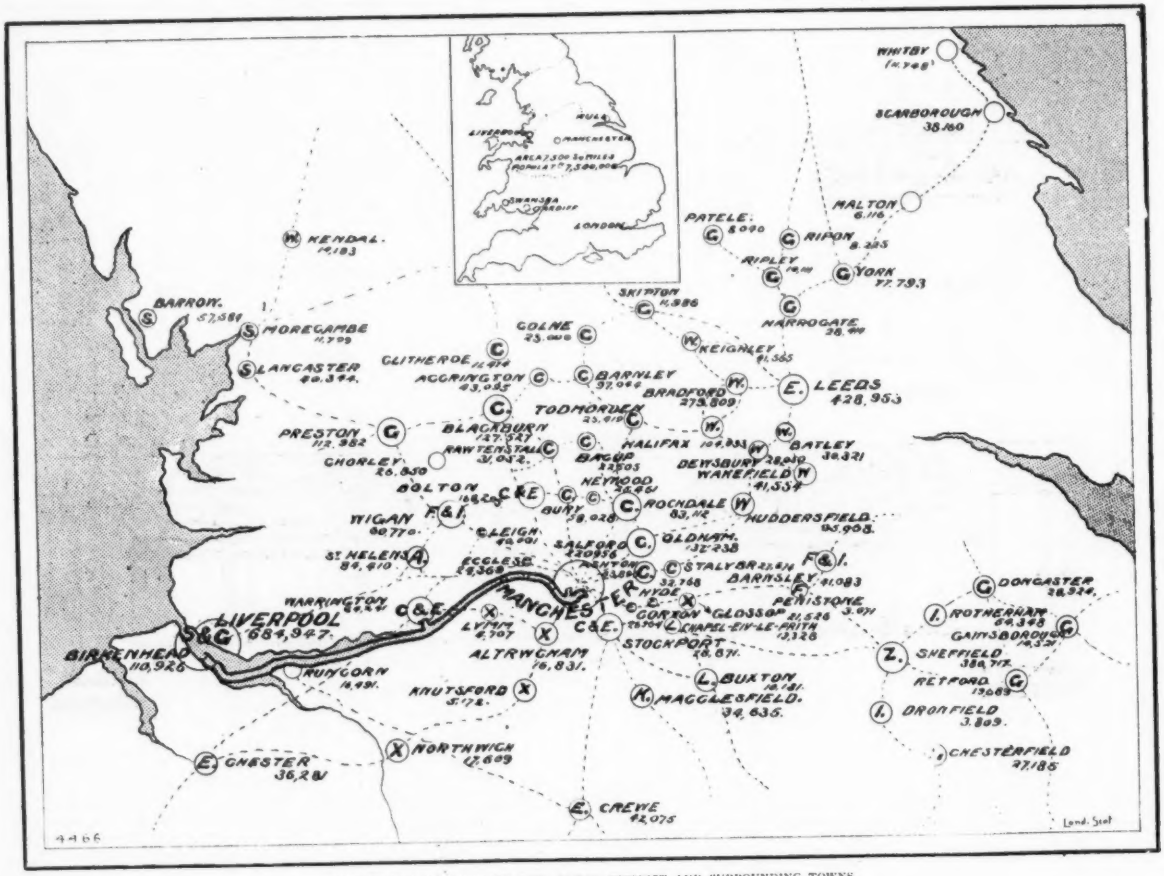
Keeping the foregoing remarks in view, we will direct our attention to the generating station, which, by its economical production of the power required, can materially assist the traction department. Although the electric lighting department should be kept distinct from that of the tramways, the former should, in small systems, supply the electricity, and if matters are properly adjusted, the common generating station should be in a position to pay its own way when the capital expenditure for plant is wiped out by the aid of the profits derived from the sale of current to the tramway department. Although it would be advantageous to the corporation, as a whole, that this should be done, it would nevertheless, be detrimental to the success of the tramway department, unless a very careful adjustment was made between the two consuming departments.

To absolutely prevent any inequalities in the adjustment of the proportion of expense to be borne by the two departments, it is, no doubt, better that the tramways department should generate their own power, especially in the case of systems requiring a constant load for 300 or more cars. Electric lighting committees generally state that their conditions of supply to the tramways department will be the actual cost of production. At first sight these terms seem reasonable, but after taking into consideration the tramway depreciation charges, tramway sinking fund, and, further, the proportion of interest on capital upon the whole of the electrical department, which they have to pay, it is very often the case that the tramways have to pay an undue proportion for departmental depreciation. In some cities, for example, the feeder cables are charged against the "tramway department," and not against the "electricity department," as the latter is the department from whom the tramways are only buying their electricity.

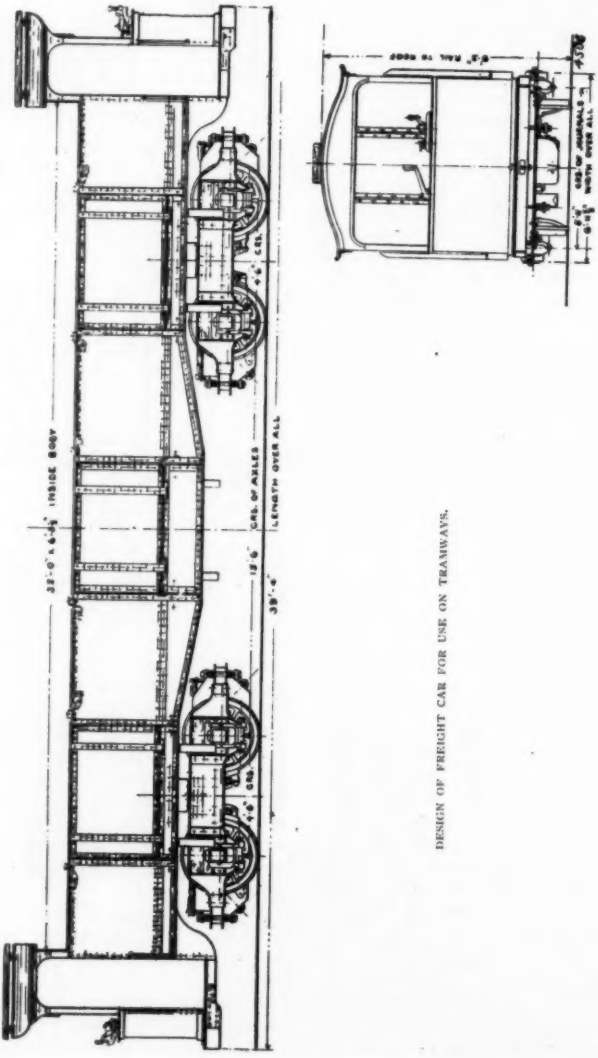
A further circumstance contributing to the fact that tramway departments can, and do, generate their own power cheaper when they do it themselves, is that the tramway department has to maintain a continuous load, from January to December, of fifteen to eighteen hours per day, whereas the electric lighting department has only the full load for about 12 hours a day during six months in the year, and for that period they have to keep a big power plant standing half the time earning no revenue, whilst all the standing charges are going on. This is handicapping those tramways departments who buy their electricity from the electricity department, inasmuch as they have to pay an undue share of the depreciation on plant which is standing idle. Finally, many generating stations will need to be so extensive in the near future that it will become imperative for tramway departments to provide their own generating plant.

Carriage of Goods.

Electric tramways unquestionably confer great benefit upon the public. How much more so will this be when the tramways authorities take up the question of carrying goods after the passenger traffic ceases at night, and specially constructed goods cars run to and connect outlying districts. As a fair example of the application of this system we will take Manchester, the ship canal district, and the surrounding towns, with their heavy street traffic and enormous carrying trade. Throughout this district, although threaded by a network of railways, a large saving in the cost of carriage, especially on coal, coke, building materials, and such goods as are generally carried by railway companies and general carriers, would be effected. Just as the trains and trams in passing through outlying townships



MAP OF THE MANCHESTER SHIP CANAL DISTRICT AND SURROUNDING TOWNS.



DESIGN OF FREIGHT CAR FOR USE ON TRAMWAYS.

convey people from their homes to their business, so, with a view to developing goods traffic, should the tramway system afford facilities for connecting works, factories, etc., and agricultural enterprises with its system. Especially would the advantage of such a scheme be felt in a place like Manchester, with its manufacturing and agricultural centres so widely distributed. To take an instance, the last agricultural returns for Cheshire state that 340,000 acres are under permanent grass, and 25,000 acres under potatoes: taking an average figure of five tons of potatoes per acre, and assuming that only one-twentieth of these potatoes are brought to the Manchester market, we find there are about 6,250 tons to transport annually.

Briefly, the advantages attaching to the utilisation of tramway systems for the carriage of goods are as follows:—

1. The fostering of trade and industry.
2. The abolishing of heavy wagon traffic, with its heavy wear and tear on the roads and tramway lines, and as a consequence the reduction of the cost of maintenance.
3. Giving increased facilities between manufacturer, warehouseman and buyer.
4. The quick transit of goods, especially at depôts where light railways meet tramway systems termini.

An ideal scheme for the conveyance of goods from any one part of such an area as exists in the vicinity of the Manchester ship canal, for example, should comply somewhat with the following conditions:—

1st. The goods should be loaded on the cars direct from the ships, mills or warehouses and deposited, without further handling, at their ultimate destination.
2nd. Special sidings should be run in from the roads to mills, warehouses, etc.
3rd. Goods should be assembled in such a way as to cause no delay in transit from the loading point to the destination.
4th. One or two special standard trucks should be used for all classes of goods.
5th. The service should be expeditious, but not necessarily entailing a high rate of speed.
6th. The conveyance of goods should not in any way interfere with any passenger or ordinary road traffic.
7th. The maximum weight to be carried on each truck should not be less than 10 tons for merchandise and 20 to 30 tons for material in bulk, such as coal, etc.
8th. Special care should be given to obtaining the services of a well-organised staff at the loading depôts and termini.

There will never in all probability be a free interchange of rolling stock between the railway and the tramway systems, as certain essential differences in the constructive and operative methods tend to reduce that economy which might otherwise be expected to result from such a practice. No tramways of standard gauge laid on public roads in this country will admit the ordinary rolling stock of railways, because the depth of the wheel flanges in the latter and the width between the tyres are not accommodated by the grooves of the tram rails.

Neither would it be convenient to relay our tramways to accommodate the ordinary railway rolling stock, or to alter the wheels of the latter to suit the existing tramways. The expense of equipping the goods and mineral rolling stock of railways with efficient motors to render it self-moving over the ordinary tramway gradients would not be economically justified by any reasonable expansion of the tramway system.

There is, however, a field for the employment of special rolling stock, for the conveyance of goods either by tramway or by railroad, between a producer and consumer's premises which are in connection with one or the other of these systems; a good instance of such traffic being found in the case of tramway systems in the neighbourhood of colliery districts, where a few connections from the tram lines to the pit railways serve to bring the coal producer and the coal consumer into close and economical contact.

To meet the requirements of such a

case, Messrs. Sheffield and Twinberrow, of Newcastle-on-Tyne, have designed the vehicle shown by the illustration on page 62. The body of the wagon comprises two hoppers, the combined capacity of which is equal to from 28 to 30 tons of coal; the ends and the lower parts of the sides converge sharply to two openings, through which the load is discharged when the doors are withdrawn towards the middle of the wagon. It is not essential that the whole of the coal should be discharged at one spot, as the doors are arranged to be capable of closing after any desired quantity has been delivered.

The sides of the wagon form a pair of girders 6 ft. in depth, well stiffened and braced together; the incline ends are continued downwards to form a footplate at each end, the controllers' breakgear, etc., being housed within the driver's cab.

The main transoms of the body, which are arranged in pairs over each bogie, serve to transmit the load to groups of helical springs, which are compounded for efficient action both when the car is loaded and when it is light. The bogie has flanged plate frames and steel axleguards, helical springs being interposed between the frames and the axle-box. As the load is supported by these latter in series with the transom springs, a very easy motion is assured.

The bogie frames are extended beyond the wheels and braced together by curved headstocks of channel section, which serve for the nose suspension of the motors.

When four motors are fitted the whole of the gross load is available for adhesion, and the car will work over gradients of 1 in 10 in all weathers. On flatter grades trailer cars may be added to an extent which is limited by the torque exerted by the motors. The car illustrated is capable of hauling one trailer of similar capacity up five per cent. grades or two trailers up three per cent. grades. On a level track the loaded car will haul seven loaded trailers with the controller in the notch for highest speed. The adoption of self-discharging hopper wagons results in a large saving in the labour of unloading coal or similar bulk freight.

The patentees have designed various types of cars with level floors and side doors to suit the carriage of general merchandise, and the method of discharge usual in places which are not fitted with depôts suited to the self-discharging type.

In conjunction with the foregoing, an opportunity has been afforded me to present the opinions of several managers and engineers connected with large tramway undertakings, to whom the writer tenders his best thanks.

SCHEDULE OF QUESTIONS ON ELECTRIC TRAMWAYS.	OPINIONS EXPRESSED by Dr. W. G. Rhodes, M.I.E.E.
Are you of opinion that electric traction can make faster and cheaper communication between the country districts and towns to the great advantage of industries generally?	Yes, electric street tramways have the great advantage of picking up and setting down passengers anywhere, thus saving the time taken in going to and from railway stations. Experience also proves that cheaper transit is provided by electric traction.
What is your opinion as to the free use of ordinary roads for intercommunication of electric tramways, provided the travelling public is not handicapped?	The use of ordinary roads for electric tramways is necessary in systems connecting large towns with the immediate suburbs, but on going a considerable distance through a country district the track should be on land of its own.
What is your opinion of the carriage of heavy goods by electric tramways, having special day cars for parcels and light goods, with depôts for collecting and distributing the same?	I am entirely in favour of special cars for carriage of light goods and parcels on any tramway system, both for public convenience and to augment receipts, but heavy goods can only be handled satisfactorily on country railways, which may, of course, be electric light railways.
What do you consider the main advantages of electric traction over horse traction?	The advantages of electric over horse traction are too numerous to mention; perhaps the chief are quicker and cheaper transit, and the abolition of the frequent heavy strains on horses at starting.
Collecting town refuse.	I cannot express an opinion on this point.
Street watering.	Street watering cars should be provided in all cases.
Contract tickets.	I strongly advocate contract tickets for through routes.
Direct cars from terminus to terminus.	Direct cars from terminus to terminus would only pay at certain hours of the day.
Intermediate cars, with special rates for a number of tickets.	Only at certain hours of the day.
Return tickets.	No.

SCHEDULE OF QUESTIONS ON ELECTRIC TRAMWAYS.	OPINIONS EXPRESSED BY **J. B. Hamilton, Esq.,** General Manager, The Leeds City Tramways, Leeds.	**T. L. Miller, Esq., M.I.E.E.**	**Wm. J. McCombe, Esq.,** Tramway Manager, Corporation of Kingston-upon-Hull, Tramway Office, Osborne Street, Hull.
Are you of opinion that electric traction can make faster and cheaper communication between the country districts and towns to the great advantage of industries generally?	I am undoubtedly of opinion that electric traction can provide faster and cheaper communication than previous forms of tramway traction.	I am very doubtful if electric traction will provide quicker communication between country districts and towns where such districts are at present served by the railway companies, but I have no doubt at all that in the majority of cases the quicker service, or rather more frequent service, will prove much more convenient and cheaper, and will thus be of advantage to the industries generally.	Certainly.
What is your opinion as to the free use of ordinary roads for intercommunication of electric tramways, provided the travelling public is not handicapped?	I think no yearly way-leave should be charged for ordinary macadamised roads in purely rural districts.	I am favourably disposed to the free use of the ordinary roads for intercommunication of Electric Tramways, provided the travelling public is not handicapped, and that the tramway company pays its fair share towards the maintenance of such roads.	Free use is a large order, and the matter might be looked at from many points. Intercommunication is certainly desirable.
What is your opinion of the carriage of heavy goods by electric tramways, having special day cars for parcels and light goods, with depots for collecting and distributing the same?	I think this is quite practicable for reasonably heavy goods in districts where the passenger service does not require to be very close.	I think much may be done in the way of carrying heavy goods by Electric Tramways from country districts to towns, and between towns having tramway communication; but I see considerable difficulty in providing for mixed parcels and light goods traffic and passenger traffic in large towns, such as Liverpool, Manchester, Glasgow, etc. In such cases possibly the most satisfactory arrangement would be the use of motor-cars for the collection and distribution of parcels and goods, and the provision of special lines from the depôts connecting such depôts with the lines outside the towns, and communicating with the outside districts. If the goods traffic only takes place at night, the provision of special lines within the large towns would not be necessary; but I fear it would be very difficult to work a "mixed traffic" in the towns I refer to.	Have not considered this.
What do you consider the main advantages of electric traction over horse traction?	Speed, comfort, economy, practicability.	Briefly, the main advantages of Electric Traction are quicker and more frequent service, and lower operating costs.	Higher speed, easier running, economy in working, greater carrying capacity of cars, and greater pleasure in use.
Collecting town refuse.	In large towns I do not consider this practicable.	As the Tramways will only be laid in the main thoroughfares, and as the collection of refuse entails the carts going through all by-streets, I am of opinion that this service will be more satisfactory performed by means of motor-cars.	See No. 3.
Street watering.	Quite practicable.	Street watering, in my opinion, will also be more satisfactorily carried out by motor-cars.	I do not see any reason why street watering should not be efficiently and well performed by electric cars.
Contract tickets.	I do not think these are advisable.	This is a matter certainly for the tramway manager.	They are a source of trouble and difficulty with cheap rates. Ready-money is preferable.
Direct cars from terminus to terminus.	Depends upon the route and the necessities of traffic.	Are matters dependent very much on local conditions, and I do not think any abstract opinion would be of much value.	Yes, if practicable. Not under all circumstances.
Intermediate cars, with special rates for a number of tickets.	Ditto.		The practice seems likely to grow in popularity. It ought to be feasible in very large centres.
Return tickets.	I do not consider these advisable.		See No. 7.

SCHEDULE OF QUESTIONS ON ELECTRIC TRAMWAYS.	OPINIONS EXPRESSED BY			
	A. S. Giles, Esq., M.I.M.E., Chief Electrical Engineer, Blackburn Corporation Tramways, Blackburn.	**A. H. Gibbings, Esq.,** M.I.M.E., Engineer in Chief, Stalybridge, Hyde, Mossley, and Dukinfield Tramways and Electricity Board.	**C. C. Atchison, Esq.,** A.M.I.E.E., Borough Electrical Engineer, Rochdale.	**H. C. Bishop, Esq.,** Chief Electrical Engineer, Wigan.
Are you of opinion that electric traction can make faster and cheaper communication between the country districts and towns to the great advantage of industries generally?	Yes.	Yes; this is the object of the South Lancashire tramways system. It is in strong evidence in nearly all the large centres of population in the U.S. of America.	Yes, for suburban and local country traffic, but not for long distances' traffic, and facilitate inter-urban running.	Yes.
What is your opinion as to the free use of ordinary roads for intercommunication of electric tramways provided the travelling public is not handicapped?	I do not quite understand the question. It seems to have a philanthropic sound. Intercommuuication must be carried out on the lines of running powers, such as in the case of railway companies. Municipalities cannot give anything away with an equivalent return.	This is a difficult question to answer. It involves the question of repairs and maintenance, width, and right of others to the subsoil.	All tramway routes should be as much interconnected as possible, with running powers on all routes, power being supplied by the local station, and connecting tracks laid, though they may not be specially well paying. Tramways should not only be laid in paying districts, but bad routes obliged to be taken with the good. A standard gauge should be used throughout and made essentially a condition of granting tramway powers.	Should be given every opportunity.
What is your opinion of the carriage of heavy goods by electric tramways, having special day cars for parcels and light goods, with depôts for collecting and distributing the same?	I think there are few towns could afford to have special cars for goods and parcels, and the difficulty of unloading on the main lines, which would interfere with the ordinary traffic, would be considerable. Such cars could carry parcels from terminus to terminus profitably, provided there is sufficient freight.	See my pamphlets.	For local conveyance, probably in connection with district goods yards. All cars should be provided with special parcel-carrying arrangements to parcel depots and also letter boxes, parcels carried for local post-offices and letters in bulk, and subsidised by Government.	A means of carrying goods very cheaply.
What do you consider the main advantages of electric traction over horse traction?	Lower cost of working and greater speed.	Speed, comfort, and cleanliness of road.	Cheaper working, less wear of roads, safer, quicker, more cleanly for the roads and reduction of scavenging.	Speed and cost of running.
Collecting town refuse.	This would be, of course, feasible if the destructors are situated suitably for all routes of tramways.	See pamphlet.	All night, yes; but in the day time the main consideration to be dealing with passenger traffic, parcels, etc.; purely auxiliary and not a main consideration.	A good idea that I have already considered and hope to have adopted.
Street watering.	Yes; have a machine which I am adapting to the purpose.	Comes more under motor-waggons than electric tramways.	Where possible, yes; but not to interfere with rapid transit.	Not much good, in my opinion.
Contract tickets.	Have not had to consider the question yet.	Most unsatisfactory and objectionable. There is no analogy in this respect between a railway and a tramway.	Yes, both for ordinary and workmen's cars at different rates.	A lot of trouble and a great liability of fraud.
Direct cars from terminus to terminus.	Have run such cars for special occasions, such as football matches.	Each must be considered on its own merits.	Yes, through-cars without stops of any sort on short lines, otherwise about a mile run without stop and special fares.	Good if traffic is sufficient.
Intermediate cars, with special rates for a number of tickets.	Anyone may charter a special car by giving notice beforehand. The price is by agreement.	Ditto, ditto.	Otherwise workmen's cars at all times of the day. Not only at certain times of the morning, mid-day and evening. Possibly at holiday times excursion cars, or ordinary times special cars for parties.	Have not considered it.
Return tickets.	Have not had to consider this question yet.	Yes. Should be a great boon to artisans and others.	Yes, in all cases.	Good on suburban lines.
			REMARKS. — Electric tramways should have as first consideration quick traffic between local centres, tied at each of these by stopping cars, passenger traffic being the main item; goods, parcels and post-office arrangements, etc., all subsidiary; through cars slightly higher fares than stopping cars, workmen's stopping cars only; use the line at off and night times for whatever purposes possible, and special cars provided for such work, the majority of such work to be done at night; during the day greatest possible facilities for running over any routes.	

OPINIONS EXPRESSED BY			
S. J. Watson, Esq., M.I.M.E., Chief Electrical Engineer, Bury.	**W. P. Wright, Esq.,** C.E.E., Electrical Works, Bootle.	**Charles Challenger, Esq.,** Traffic Manager, The Bristol Tramways and Carriage Company, Limited, Bristol.	**A. R. Fearnley, Esq.,** General Manager, Birkenhead Corporation Tramways.
Yes.	Given an intimate knowledge of the requirements, it should be possible to make more use of electric traction in this direction.	I have not given this subject consideration.	Yes.
Do not quite understand its terms "free use of roads." In the case of rails being laid, the road authority would have to be indemnified against extra wear or loss of surface. Intercommunication between districts would be wanted. Mutual running powers would probably settle the matter.	An electric tramway should pay rent for use of way-leave.	Ditto.	Do not suppose that tramways will be allowed use of roads without paying rates and taxes.
Undoubtedly much will be done in the near future in this direction, although very little has yet been done. Wide field for development.	In turn I presume? Not a very feasible arrangement at present.	Ditto.	Am waiting developments; can see a great many objections.
Clear streets. More rapid and regular service.	Cheapness of transport per ton mile.	See my article, "Horse Traction and Electric Power," in the *Railway World* about 1898. I have not altered my opinion since writing that article.	Speed, cheaper to work, cleanliness.
Doubtful whether much will be done in this direction, as the mileage of streets provided with rails will be small compared with the streets to be scavenged.	Costly.	Not given the subject consideration.	No.
The provision of local dépôts might, probably would, assist this to be carried out.	Hardly worth it, owing to small proportions of mileage available for this method.	Ditto.	Might be done to a certain extent.
On main roads easily done.	Too cumbersome.	Not in favour of them.	Not feasible under present systems of collecting and checking fares.
Essential.	Depends on each individual section where traffic sufficient worth while.	Admissible only on long lines (five miles and upwards); and then, if a frequent service is run, "stopping" cars would have to shunt to make way for fast cars. A difficult problem.	Have been tried, but caused a great deal of dissatisfaction.
Through running is sure to be used to prevent long stops in centre of town and crowded streets.	Not much gain in time possible on same rails. Not worth while; people want to board first car coming along.	Not considered subject.	Think charge should be by distance.
Very little advantage to travelling public, and should say none at all to tramway authorities.	Cheaper flat rates more desirable. REMARKS.—I advocate, first, universal fares, except under special conditions where the objection can be made valid. No transfer for urban service. Different cars for inter-urban service, each car having one fare if possible.	Not in favour of system. REMARKS.—See my article, "Destination and Route Indicator," in the August *Light Railway and Tramway Journal*, and in the *Railway World*, for some possible hints.	Are being worked at the present time and found satisfactory.

(Concluded in the next Number.)

Workshop Practice

Practical suggestions for this section are invited, which, if accepted, will be suitably paid for. Wherever possible, drawings should accompany the contribution; rough sketches will suffice. Nothing will be too poor for a careful inspection. See important announcement in advertisement pages.

Temporary Repair to a Single-Phase Motor.

When an armature coil "burns out" on a single-phase alternator and a similar one is not in stock, the coil may be disconnected and the adjacent ones connected together. The machine can then be run as formerly. The speed will require to be slightly increased above that at which it usually runs for the same load. When this alternator is required to be run in parallel with others much discretion will be required in handling it. There will be a tendency to pull out of step: this can, to a great extent, be avoided by over-exciting the field of another alternator. By doing so one increases the tendency of that machine to maintain a higher voltage at its terminals. Whatever the momentary variation of the driving power may be this alternator's terminal voltage will be slightly greater than the bus-bar volts. Hence it will not be motored by the other machines. On the contrary, there will be a constant tendency of current to flow back to the others, motoring them quickly, and so lessen the tendency to pull out of step. The effect of this controlling current will be most pronounced on the machine with the missing coil, and it will help in a great measure to keep it in parallel with the others. This method may be resorted to with high-speed direct-coupled sets. The extra exciting current, or rather the extra H.T. current generated by it, acts as a governing or regulating current in the circuit. But it does not succeed to the same extent when the engines have large fly-wheels, as they will not alter so readily. W. W.

Electrical Measuring Instruments.

When using delicate electrical measuring instruments a frequent source of error is due to wiping the glass in front of the dial just before taking a reading. This electrifies the parts rubbed, and the moving parts become electrified by induction. So they are subject to electrical forces other than those they are intended to measure. Hence such rubbing should be avoided, as it causes great discrepancies.

W. W.

To Mark an Incandescent Lamp.

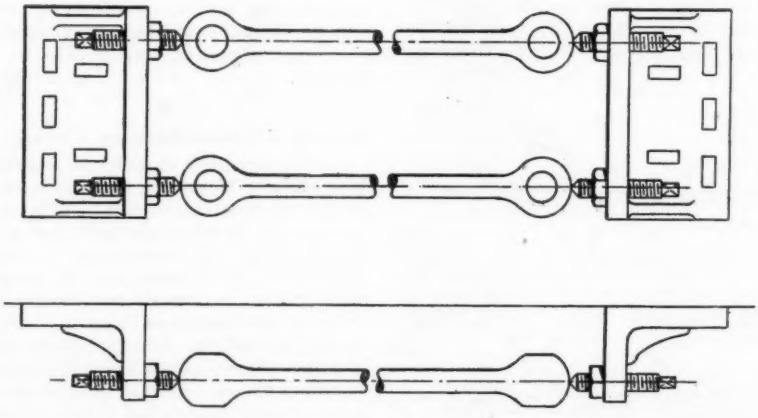
For obvious reasons, it is often desirable to mark an electric lamp in such a manner that it can be identified afterwards. A method of doing this that cannot be defaced is to draw a circle round the edge of the cap and the glass with a pen. The ink will sink in between the plaster and the cap, thus colouring the plaster of Paris in an irregular way. If other persons are not informed, it will never suggest itself how this was done. This method has been useful to the writer, who discovered it accidentally. W. W.

Planing Parallel Rods, Etc.

The rig here described may be used with great advantage on a planing machine for planing the ends of connecting rods, etc., required to be parallel. The arrangement consists of two ordinary angle plates of suitable size, which should be bolted together with the bottom faces level. Two holes are then marked off about 18 ins. apart and about 2 ins. from the top of the

plates, and drilled and tapped with 1¼-in. gas-thread; four steel centres should then be turned and screwed a good fit into the holes, a square being milled on one end to allow for tightening with spanner, the other end being turned to a centre point of 90°, the nuts on the inside of the angle plates locking the screws when tightened up. The rods are put in the centres after they are turned, and suitably packed up from the table to keep them from rotating while being operated upon. Preferably two can be machined at once when double tool-boxes are available, and on the completion of one side parallel packings are used to ensure uniform thickness. These centre plates will be found useful for various jobs, the easy withdrawal of the centres leaving them again ready for ordinary use.

J. GREEN.



PLANING PARALLEL BARS.

Modernising an Old Engine.

A year ago an old steam-engine in my charge required a great deal of continuous repairs. The cylinder is 18 ins. diameter, 2-ft. stroke; speed, 80 revolutions per minute. A 4-in. steam-pipe and 4-in. throttle governor valve were fitted. This engine was originally designed to work with a steam pressure of 40 lbs., and with this pressure I am told that it worked very well. Some time ago new boilers carrying 100 lbs. pressure were put down in place of the old ones. With this increased pressure the engine ran quite irregularly in alternate periods of racing and steady or easy running, and the wear and repairs became heavy and continuous. After a little thought the following alterations were decided upon. The slow-speed governor and valve were replaced by a high-speed governor and a smaller valve. Taking the area of cylinder as 260 sq. ins. and the inrush of steam at 10,000 ft. per minute, the piston speed being 320 ft. per minute, the area of governor valve becomes

$$\frac{260 \times 320}{10{,}000} = 8{\cdot}32 \text{ sq. ins.} = 3\tfrac{3}{4}\text{-in. bore.}$$

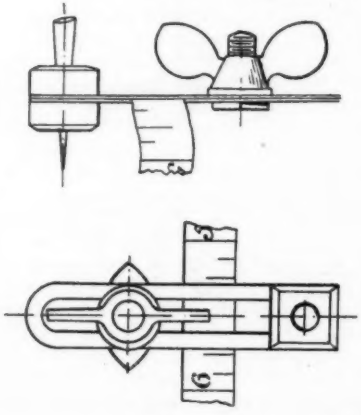
Although this is ¾ in. less bore than the old governor valve, it was considered too large, and the area was obtained as follows. The 4-in. stop-valve was put into good order, and with the heaviest load on the engine the steam opening was measured. Thirty per cent. was added to the area thus obtained, which gave an area of 5 sq. ins. A 2½-in. valve and governor was fitted. The result was most satisfactory—very steady running and a reduction of 75 per cent. in repairs.

REPAIR ENGINEER.

A Template Appliance.

The illustration below represents an appliance useful to template makers for describing large circles or parts of them too big for trammelling. It consists of a small brass stock, forming a cube of $\frac{1}{2}$ in. side, in the centre of which a hole is made to suit the usual draw-point. A groove is then cut on each side of the cube to allow the jaws, which hold the tape, to fit in, after which they are soldered to the stock. The tightening apparatus is a $\frac{3}{4}$-in. by $\frac{1}{4}$-in. bolt, with washer for holding tape in position. The jaws should have a space wide enough inside to allow a proper sight of the divisions on the tape, also whatever size is wanted should be placed exactly in line with the draw-point hole and centre line. Handy size of tool: cube, $\frac{1}{2}$ in. side; jaws, $1\frac{7}{8}$ in. or 2 ins. long; width inside, $\frac{1}{4}$ in.; bolt, $\frac{3}{4}$ in. by $\frac{1}{4}$ in., with washer. By slackening the wing nut the appliance can be moved along the tape to the required distance without being taken off.

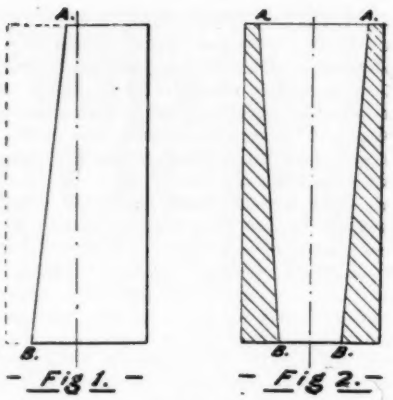
E. Fleming.



A TEMPLATE APPLIANCE.

A Taper Gauge.

A simple method of forming a taper gauge is by taking a piece of tube (preferably steel), and having an internal diameter larger than the greatest required on the taper. The tube is then milled



A TAPER GAUGE.

or filed diagonally to meet the required diameters, as shown at Figs. 1 and 2, the opening at *A* and *B* being kept smaller than the finished sizes to allow the thin edges on the inside to be filed up.

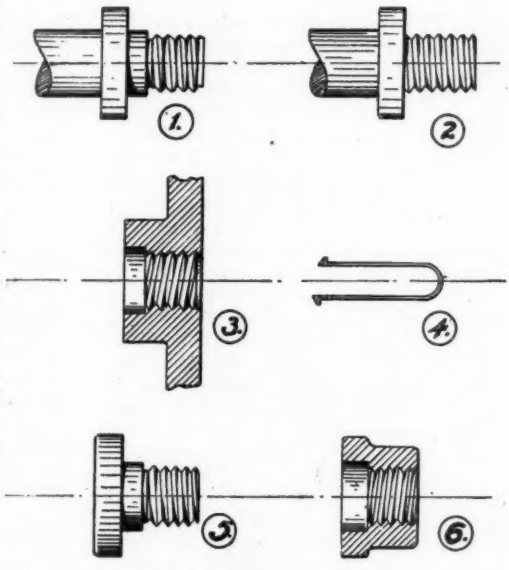
F. Smith.

Fitting a Face-Plate or Chuck.

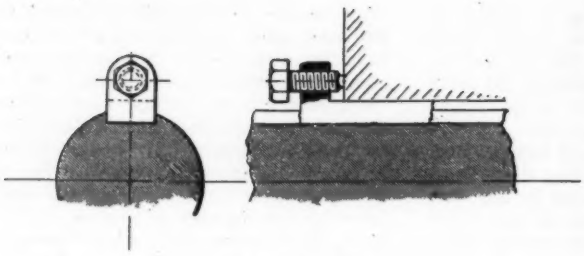
To fit a face-plate or chuck in a satisfactory manner is not so easy a job as expected by most mechanics. This, to a great extent, is due to the fact that most manufacturers of machinery, to which chucks have to be fitted, have a standard of their own as regards number, outline, diameter, and length of thread. This, no doubt, is much to be regretted, as often one face plate or chuck would do in place of two or three. A little more skill and experience to fit such odd threads without proper templates requires a greater capacity than that of the average mechanic. The thread on the spindle is very often cut in such a way that it is impossible for anyone to make a satisfactory job, as the design may be at fault. A good-fitting chuck which has been turned on a well-designed and properly cut spindle will, when removed and replaced again, run true within limits which may be ignored in the best engineering. In order to obtain such results the spindle must be made as shown in Fig. 1, and not as

Fig. 2. The face in Fig. 1 should be straight, and the diameter of the plain part to be a few hundredths of an inch larger than the thread diameter, the latter to be completely finished in the screw-cutting lathe and not by hand. Whenever possible, the finishing cuts on these parts should be taken when the spindle has been carefully adjusted in its own bearing; but this can only be done when the spindle is for a screw-cutting lathe; unless, as is sometimes done, the whole headstock is clamped by means of special packings to the lathe bed, and the spindle revolved by a suitable driver. Another good way is to have the spindle revolving in a strong, well-adjusted stay; but good results, however, are obtained by turning between the centres, if the finishing cuts of the bearing and spindle nose are taken last of all. As to the fitting of the plate or adaptor, this should be roughed out all over, either being gripped in a jaw-chuck, or having the hole bored smaller than the bottom of the thread, placed on a mandrel and turned between the centres. It should then be bolted to a small face-plate of a lathe, so that the two can be removed bodily to try on a spindle, and easily be put back if required. The face, Fig. 3, should be straight, and the recess should be made from ·0002 to ·0004 smaller than the diameter of the spindle to ensure a perfect fit. The thread may be a free fit, but to be the same outline as thread on spindle, and concentric with the recess. Diameters should be measured with a micrometer or slide gauge, and transferred by means of inside micrometers or calipers. The bottom of the thread may be obtained by means of a thin pair of calipers, or to measure the depth of thread with a depth gauge, and deduct twice that amount from the top diameter. If the pitch of the spindle nose is so coarse that the jaws of the micrometer drag between, a packing of an exact known thickness may be employed.

When the form of thread is not a standard, the same kind of gauge should be used in making the tool. A very easy and convenient method is to use a piece of sheet lead cut and beaten to the form of the thread. The plate should first of all be bored out to the bottom of the thread, and then turned out to the top of the thread for about one-pitch depth; this serves as a guide when cutting the thread. The tool is fed forward till it just scrapes the recess. When the thread is finished, the recess is then bored to its proper size. To ensure success, the threading tool should be as strong as possible, to have the correct and equal amount of clearance on both sides, and the carriage should not move too freely on the lathe bed. If the outline of the thread is rather great, the finishing cuts may be taken in steps and at a reduced speed, to prevent chattering. When trying on the spindle a little oil should be applied to prevent grating. No difficulty need be feared in taking another light cut if the tool be hard and sharp.



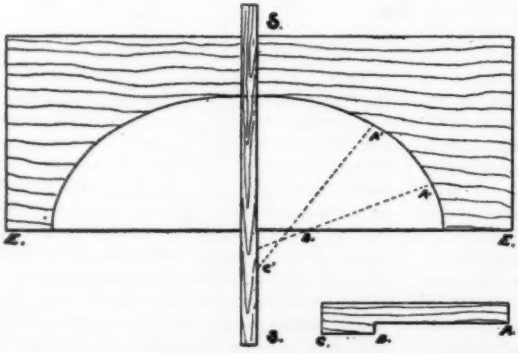
FITTING A FACE-PLATE.



SLACKING BACK KEYS.

If the job is an adaptor for a jaw-chuck it should, after being fitted to spindle, be turned to fit the recess of the chuck. A universal chuck may, at times, have to be screwed so that the jaws run true; this may be easily done by screwing the chuck on to a true running face-plate, and then cutting the thread. To prolong the life of the spindle thread, the beginning should be cut away to a sharp full thread, this will force out the dirt, and so prevent excessive wear. The instrument, Fig. 4, will be found very useful for cleaning out internal threads; but a freely fitting plug, Fig. 5, screwed in when chuck is not in use, is by far the best. It is also advisable to have a screwed bush, Fig. 6, to fit spindle nose, to protect the same when chuck is removed.

H. HELLFRITSCH.



ELLIPTICAL TEMPLETS.

The "Slacking Back" of Keys.

In practice it frequently happens that when a key has been inserted and driven home, and the various parts of the machine assembled, it is with the greatest difficulty removed, or indeed in many cases quite impossible to remove it. Motors and dynamo-machines, fly-wheels and gearing are examples. This difficulty may be completely overcome, and the tightest key removed by the following simple device. The head of the key is made rather large, and a set screw fitted into this projection as shown; on tightening up against the part, the key is easily moved.

H. H. BROUGHTON.

Elliptical Templets.

In working the patterns for fly-wheel arms of elliptical section a ready method of striking out a templet for use thereon is as follows:—Take a piece of thin timber about $1\frac{1}{4}$ in. wide and equal in length from *A* to *C* to *half* the conjugate diameter of the ellipse. From one edge cut back about $\frac{1}{2}$ in. as shown, the distance from *A* to *B* being equal to *half* the transverse diameter. Straighten edge *E E'* on a piece of templet timber, say $\frac{1}{4}$ in. thick, and at right angles fix a strip *S S'*. With a pencil held at *A*, move strip along, keeping *B C* against *S S'* and edge *E*, thus describing half the contour of templet. By moving strip to other side of centre line and repeating the operation, the half-section templet is completed. The dotted lines show varying position of strip supporting pencil.

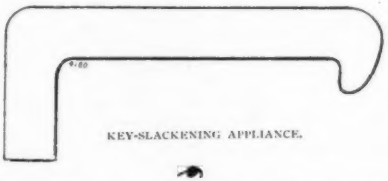
H. L. B.

A Key-Slackening Appliance.

Gib-headed keys have been a frequent source of trouble

to the mechanic who has been called upon to loosen them from a position where the ordinary key drift has not been available, or the key has become tight through long location, rust, or other causes. The illustration shows a very effective appliance for the withdrawal of obstinate keys, and is made from a piece of mild steel about 1¼ in. square section. The long end, which is bent at right angles, receives the blows of the hammer, the short end fitting over the gib or head of the key. It is a tool in frequent demand after its introduction, and rarely fails to achieve its object.

J. B. DOUGLAS.



KEY-SLACKENING APPLIANCE.

Fitting up an Old Turret Lathe.

We have in the shop an old turret stud lathe. It consists of a four-speed single-gear headstock with screw-up 3-conical-die chuck for round stock up to 1½ ins. diameter, and a turret with cross slide mounted upon a hand-traversed saddle.

The turret stands, after the old style, in front of the work and is about 7 ins. in diameter, having six tool-holes bored radially to take solid tools of ¼-in. round steel. The centre of these tool-holes was ⅝ in. lower than the centre line of the headstock, so that, as will be seen from figure *A*, each piece of steel had to be forged to bring its cutting edge $\frac{9}{16}$ in. higher than the top surface of the shank.

The lathe is used for turning plain pins with heads, an average job being a pin ¾ in. diameter, 3 ins. long out of inch bar, and a head left on the full size of the bar and $\frac{3}{16}$ in. wide. It provided a training ground for young apprentices before putting them upon first-class semi-automatic stud lathes. The work was slow and by no means sure, consisting mainly in passing broken and low-ground tools to and from the smithy.

There were no steadies behind the work; the bar was expected to stand the weight of the cut, thus cuts were limited to $\frac{1}{16}$ in., and the pins were often eccentric or full of ridges.

Cutting-off was the sorest task of all, the chuck dies were old and the bar would lift and spring on the parting tool until either the job or the tool were torn off, the tool almost as often as the job.

We determined to reform the delinquent and make it useful as well as educational.

First, we tried tools of section steel in holders of various kinds, such as Fig. *B*, to avoid the continual forging, but the lathe was springy enough already and we soon discarded them.

Then we drafted out the following arrangement:—A plate $\frac{3}{16}$ in. full in thickness was placed under the turret.

Tools were sawn off from ⅞-in. bright steel about 4½ ins. long and milled to the following shapes for cutting, then carefully tempered.

The raising of the turret ensured the cutting edges being right in height, and this proved 50% better.

Steadies were the next obvious requirement, and the toolbox *c* was drafted and forged from mild steel. (*a*) Is the shank turned ⅞ in. to fit the tool-holes; (*b*) is the tool of ½-in. × ⅜-in. steel sunk into a slot and fastened by a wedge-bolt; (*c*) is a solid steady sunk a little deeper than the tool and fastened by a T bolt; (*d*) is a hole to take a ¼-in. steel wire for indicating the length of the pin.

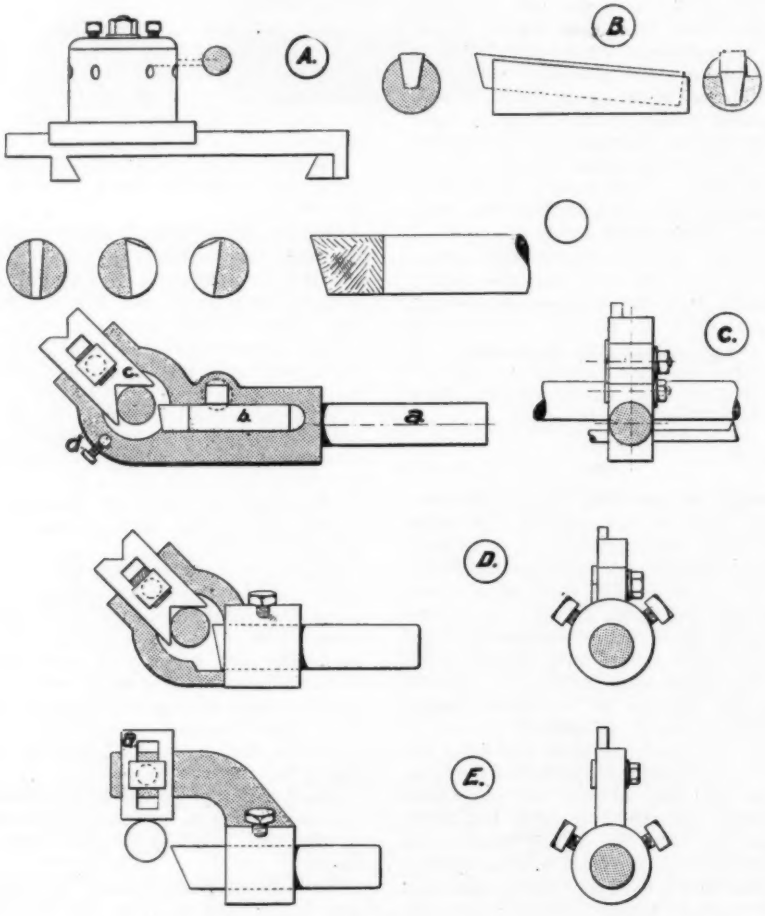
Another design of steady was made at the same time. It fastens upon that part of the tool which protrudes from the turret.

Both steadies are working splendidly, but *c* is the more easily set and the more permanent.

Finally a cutting-off steady was made, which explains itself in sketch *E*. The plate (*a*) being set to rest upon the top surface of the turned pin as the parting tool runs in. This steady has been such a success that one parting tool has been used for a fortnight with two grindings and no snips. The time for a pin ¾ in.

diameter 3 ins. long out of 1-in. bright steel formerly averaged 15 to 20 minutes, and a poor job at that. They are coming out now at four minutes each, splendidly finished without either filing or gauging.

J. HILTON.



FITTING UP AN OLD TURRET LATHE.

WORKSHOP QUERIES AND ANSWERS.

WILL some of our readers kindly answer the following?

Tube Drawing.

I have an aluminium tube, 12 ins. long, ½ in. diameter, ·05 in. thick. How can I reduce it to a gradual taper of, say, ¼ in. at the other end, keeping it a uniform thickness throughout? J. B.

Building Commutator.

Which is considered the better way to build a commutator: on its sleeve cold, and heat it afterwards; or to heat the sleeve first, before placing the commutator on it? As there is a diversity of opinion on this point, I should like to have some of our readers' opinions on it. E. C.

Polish on Turned Work.

What is the cause of the polished appearance of wrought iron and steel if soapsuds are used as a lubricant when turning the same?

Hardening Change.

What change takes place in the nature of steel when hardened for cutting purposes? H. P.

Alterations in Dynamos.

In the October issue, "Temporary Repair to Dynamo," it was suggested to cut out a defective field coil and work with the remaining good one. How to apply this to multipolar machines constitutes an interesting problem, as it is more applicable to motors than to dynamos. The latter being used to a great extent for lighting, necessitate the maintenance of a standard voltage. The former adapt themselves more readily, so more latitude is permissible in running. In the case of a four-pole motor, should it be run as a bi-polar, lifting one pair of brushes off the commutator, disconnecting a pair of coils, using the diagonally opposite pair, and should the disused pair of coils and pole pieces be removed? In similar cases with six polar machines, what is the best arrangement of brushes and field coils?

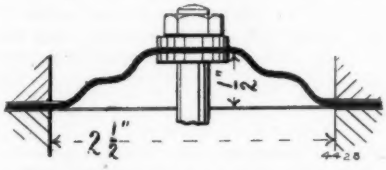
W. W.

Wood *v.* Iron Pulleys.

A great many manufacturers are fixing on line shafts wooden pulleys of American make, the makers of which claim better driving power from their use. I should like to know if tests have been made at any time which have proved their superiority over iron ones, and if they really are so? S. F.

Construction of Diaphragm.

A metal diaphragm, 2½ ins. diameter, and similar in form to the illustration, is required to stand a pressure of 350 lbs. per square inch on its under side. It is supported not only at its circumference, but also by the stay at the centre. It is



desired that when the diaphragm is thus acted upon, it shall be held by the stay with its centre half an inch from its normal position, so that when the pressure on its two sides is equalised, and the centre stay released, the diaphragm shall spring back half an inch. How should the diaphragm be constructed? DIAPHRAGM.

Foundry Practice.

How can the proper casting temperature of an alloy be best determined?

What are considered the best methods of mixing brass-founders' alloys?

Give an easy rule for weighting moulds.

Describe the moulding process known as "La cire perdu" (The lost wax).

What constitutes a "bronze" in modern engineering parlance and technical nomenclature?

Which is the best way to "kill" (to prevent liquation) lead in brass alloys?

J. F. B.

Electricity Meters.

The prevailing practice with regard to consumer's electricity meters is to instal them, and then leave them to take care of themselves for five to ten years. When they are deemed to be so inefficient as to render the substitution of new ones desirable, the makers will not take them at any price, so they help to swell the scrap heap. Has any means been devised for overhauling, cleaning, or repairing them that does not entail an undue allowance of time? If the parts are taken apart the calibration of many types is altered, which proves rather awkward.

W. W.

Wetting Tramway Rails.

Electric tramway authorities are disposed to constantly sprinkle the rails with water, even in broken or unsettled weather, often before they are entirely dry from the last rain. What renders this seemingly undue allowance of moisture on the rails desirable? W. W.

Worm Gearing.

Why does worm-gearing admit power to be transmitted in one direction only? Please explain with drawings. Show action of teeth and effect of small pitch of worm teeth. W. W.

Atmospheric Change.

Wanted, a clear and concise explanation of the atmospheric changes that lead to the load increasing suddenly on electric light stations, whatever the time or clearness of the day may be. Or does the presence of a film of moisture on glass render it less transparent to light?

W. W.

Gas and Oil Engines.

What are the relative advantages of gas and oil engines as regards cost (initial and running), up-keep, working, and efficiency?

W. W.

REPLIES.

REPLY TO B. M.

Circumference of Boiler Shell.

To obtain the length of plate necessary for a given diameter of boiler shell, proceed thus:—For a "butt" joint, multiply the outside diameter of shell by 3·1416 ($3\frac{1}{7}$) and add $\frac{1}{2}$ in. for machining edges. A certain amount of bevel is necessary, particularly if the boiler be of small diameter, otherwise the joint will "gape." No extra allowance beyond the $\frac{1}{2}$ in. mentioned above will be needed, however.

For a "lap" joint, the amount necessary for the lap must be added to the length obtained, as above. A. W. R.

[Authorities on boiler construction give for "butt" joints an edge bevel of 2 degs. = to a taper of about 1 in 30.—Ed.]

Engineering Abstracts

❀ ❀ ❀

CONSTRUCTIONAL.

Alternative Route for the Nicaragua Canal.

THE importance of good harbours for the termini of the Nicaragua Canal is so great that several less favourable features may be sacrificed to secure them. On the Pacific side, Brito is admitted to be the only available terminus, but on the Atlantic there is more choice. The author considers Greytown, the site hitherto accepted, to be unsuitable, because the harbour was ruined 40 years ago by sand drift, and the whole coast is in a state of unstable equilibrium, and has been so from remote geological periods. After discussing the physical conditions of the country at some length, the author states the alternative route now proposed from San Carlos to the Atlantic. The new line would start from the San Carlos Ridge, running down the valley of Cureño Creek, through Cureño Lagoon, and across low rolling hills to and across the Serapiqui River, thence through a more or less swampy region to the southern bend of the Colorado River, through the bayou called Rio Blanco and the Colorado Lagoon to the Colorado River, at the junction of Simon Lagoon, and finally following the river to the sea. On this route there would be no cut of more than 56 ft. to the water grade, except at one or two knife edges. The canal would be wholly in excavation from San Carlos Ridge to the sea, and the length would be ·65 mile shorter than that proposed by the commissioners, but as part of the line is along the river, where the depth varies from 18 to 30 ft., the length of excavation saved is equivalent to four miles altogether.

In the second part of his paper, the author also gives particulars of a type of dam which he believes would be especially suitable for use in connection with the Isthmian Canal, either at Panama or Nicaragua. A masonry or monolithic dam would be highly objectionable, on account of the damage that might be done to it in a few moments by an earthquake, and which might require several years to repair, and thus necessitate the closing of the canal. The author proposes a loose-rock dam, enclosed in a heavy chain-cable net, with a base of 360 ft., a crest of 10 ft., an up-stream slope of 1 to 1, and a down-stream slope of 4 to 1. The net would also be continued on the bottom of the river, above and below the dam, as an apron, 100 ft. at each end, and covered with 2 or 3 ft. of rock. This method of construction would present no difficulties, the cost would be low, it would not be injured by earthquake, and it could not slide or be overturned. A dam of this character was built some years ago by Mr. Le Baron for a temporary purpose. Although the net was made of twine, and sandbags were substituted for rock, there was no trouble. The dam stood, and resisted a pressure of 9 ft. and a flood of 18 ins. above the crest.—**J. F. Le Baron,** *Proc. Am.Soc.C.E., Oct. 1902*, pp. 688-93.

A New System of Heating Horticultural Buildings.

THE system here described is based upon the employment of a steam-jet water heater, similar in construction to an injector, and the usual heating-pipes, or coils, are rendered unnecessary. Water used for warming purposes is contained in brick channels, covered with slabs of porous stone immediately beneath the forcing-beds. These channels communicate with each other in pairs at the ends. Near the end of one channel in each pair a cross wall forms a division, and in this the steam-jet heater is fixed. When the apparatus is in operation, the water is heated and continuously circulated by steam discharged from the injector. The inventors claim that the circulation of water is rapid, that the distribution of heat is perfect, and that extremely satisfactory results have been obtained in horticultural

establishments where the system has been adopted.—**A. D. Meyere,** *Ann. de l'Ass. des Ing. de Gand*, Vol. I., pp. 227—232.

Tar Macadam.

As water and dirt perform a very large and important part in ordinary road-making, it is evident that roads so made cannot possess wear or weather-resisting qualities. In fact a few days of traction-engine traffic will "lick up" the surface, leaving the road unsafe for traffic generally. It is stated that a tarred slag road can be made at the same cost as an equal quantity of granite, that the life of the road would be five or ten times increased, and that mud and dust would be practically abolished.—**E. P. Hooley,** *The Quarry, Nov. 1902*, pp. 705, 706.

The Compressive Strength of Reinforced Concrete.

THEORETICAL considerations lead to the conclusion that the best results ought to be obtained by reinforcing test specimens according to the manner followed in ordinary practice. Numerous and varied experiments recently made have confirmed the correctness of this hypothesis. In two communications made on the 25th August and the 8th September to *L'Académie des Sciences*, a summary is given of some recent scientific results, but the scope of *Comptes Rendus* did not permit full details of the experiments to be published, nor the practical lessons which they taught to be indicated. The object of the present articles is to complete the exposition of the subject, to give the bases for calculation of resistance to compression, of concrete reinforced in various ways, and to indicate the best means of using this material in actual practice.—**M. Considere,** *Le Génie Civil, XLII., No. 1*, p. 5; *No. 2*, p. 20; *No. 3*, p. 38; *No. 4*, p. 58.

Oiled-Shell Roads.

A METHOD adopted for the construction of oiled roads in Galveston, Tex., is thus described. The subgrade of sand is first soaked with water and compacted by ramming. It is then covered to a depth of 9 ins., and rising about 2 ins. above the finished surface grade, with a mixture of 80 per cent. rotten shells, 8 per cent. terracotta clay and 12 per cent. water. It is allowed to stand until the surface is nearly dry, which usually occurs in about two days, and is then worked to grade with a 6-ton roller. Finally it is thoroughly sprinkled with crude oil, and a month later is again oiled. About 18,000 square yards of street have been surfaced in this manner, and after two months' service under heavy teams there has been no appreciable wear. If they hold up for a year, it is proposed to surface all unpaved streets in this way.—*Eng. Record, Oct. 18, 1902*, p. 373.

Armoured Concrete Construction (Hennebique System).

THE author says that M. Hennebique was the first engineer to recognise the importance of providing for shearing stresses in connection with the strength of concrete beams, and that his scientific designs have made him the most successful concrete steel builder in Europe. The descriptions and illustrations given in the paper relate to the following details:—Girders, floors, columns, foundations, piles, and sheet piles; and also to executed works, of which the following are typical examples: Quai de Billy Bridge, Paris; transportable guard-house for Orleans Railway Company; Chatellerault Bridge; Billancourt water-tower; staircase at Palais des Beaux Arts, Paris; and the dome for Museum of Egyptian Antiquities, Cairo. In conclusion, the author says that Europe is to-day in the lead of concrete-steel structures, which is undoubtedly the greatest industry to be expected in the 20th century.—**L. Mensch,** *Jour. of the Assoc. of Eng. Societies, Sept. 1902*, pp. 99—121.

Design of a Waterworks.

IN a paper read at the Annual Congress of the Royal Institute of Public Health, the author sets forth the principles governing the design of a waterworks to supply a population of 50,000 inhabitants. Assuming that a gravitation scheme has been decided upon, the engineer must determine the site and capacity of the reservoir, and consider rainfall, evaporation, percolation, and the discharge of streams. Having settled preliminaries, the engineer decides upon the class of embankment for the reservoir best suited to the site. The design and method of construction of an earthen embankment are next discussed, and the points affecting the dimensions of the culvert and the overflow weir are considered. Details relative to service reservoirs at various places are given, and the sizes of filter-beds are stated. Great care is necessary in selecting the route for the pipeline, and the engineer will have to consider the relative merits of tunnelling, cut and cover, or a conduit of pipes. Rules are stated for calculating the required diameter of the conduit, and some useful hints are given as to the application of sluice-valves, air-valves, meters, and other necessary fittings. The system of distribution, including mains, waste-detection meters,

supply meters, and hydrants, is subsequently discussed, and the paper concludes with a general estimate of cost for the complete scheme.—**W. Ingham,** *Water, Nov. 15,* pp. 449-56.

Slag in Cement Making.

SLAG cement, properly so called, is the product obtained by pulverising without calcination a mixture of granulated basic blast-furnace slag and slaked lime. Although really a pozzuolanic cement, this product is frequently sold as "Portland" cement, in spite of the fact that it differs from true Portland cement in composition and properties. It is said that the production of this material in the United States for 1901 amounted to over 272,000 barrels. The composition of good slag cements should be within the following limits :—

Silica	22-30 per cent.
Alumina and Iron ...	11-16 ,,
Lime	49-52 ,,
Magnesia (less than) ...	4 ,,
Sulphur ,, ...	1½ ,,

Portland cements can be made from mixtures of which one element is blast-furnace slag. In this case the slag is ground, intermixed with powdered limestone, and the mixture calcined and re-ground. An analysis of a representative Portland cement, made in America from these materials, is as follows :—

SiO_2	23·62 per cent.
Al_2O_3	8·21 ,,
Fe_2O_3...	2·71 ,,
CaO	61·92 ,,
MgO	1·78 ,,
SO_3	1·32 ,,
S	0·00 —
Loss on ignition ...	0·52 per cent.

In England blast-furnace slag has been somewhat largely used as an adulterant of Portland cement. As commonly practised this admixture is not to be recommended. If, however, a certain amount of finely-ground slag of proper composition be added, it should increase the structural value of the product. — **E. C. Eckel,** *Eng. Record, Nov. 1, 1902,* p. 146.

POWER.

Methods of Heating Feed-Water.

A RECENT comparison of six systems of heating feed-water gave some useful results, some of which are stated below. In the trials made the flue gas left the boiler at 500-550° Fahr., the engines were compound condensing and worked with steam at 150 lbs. absolute, with a vacuum of 26 ins., the exhaust was 125° Fahr., the hot well was at 106° Fahr. and the initial temperature of the feed was 60° Fahr. The efficiencies of the system were found to be as follows :—

No.	Details of System.	Feed.	Efficiency per cent.
I.	Vacuum heater, economiser, and electrical auxiliaries	Cold or from hot well	14·3
II.	Atmospheric heater, economiser, and steam auxiliaries	Cold	13·7
II¹.	Do. do. do.	From hot well	14·4
III.	Vacuum and atmospheric heatersand steam auxiliaries	Cold or from hot well	12·6
IV.	Atmospheric heater and steam auxiliaries	From hot well	12·4
V.	Vacuum and atmospheric heaters, economisers, steam auxiliaries, and electric fan	Cold or from hot well	14·4

An astonishingly close agreement is shown by cases I. and II¹. Contrary to general opinion, the electrical auxiliaries show no economy, and their first cost is considerably the greater. Practically no greater economy is shown by Case V., using economisers with motor-driven fan, vacuum and atmospheric heater with steam pump.—*Power, Nov. 1902,* pp. 26-29.

Problems in Valve-Gear Design.

THE author suggests a new and simple method for finding accurately the radius of small lap-circles. This should be useful to draughtsmen, who know the difficulty of correctly judging the point of intersection of an admission or cut-off line with the valve-circle when the lap is small.—**W. C. Kretz,** *School of Mines Quarterly, July, 1902,* pp. 308-36.

The Champ Generating Station, Grenoble, France.

ONE of the most interesting central stations is certainly that lately installed at Champ-on-the-Drac, 15 km. (9½ mls.) above its confluence with the Isère (observes M. A. Dumas, in the *Génie Civil*), on account of the novel works for utilising the difference of level in the stream and the generation of current at a tension of 26,000 volts. This station is intended to supply power for the various industries in the Fure and Morge valleys ; but not lighting, which is already provided for. The bed of the Drac, which was confined within narrow gorges, spreads itself out, from Saint-Georges-de-Commiers, into a vast plain levelled by the detritus brought down during freshets,

the volume of which may attain 1,200 cub. metres (264,000 gals.). The width of surface covered by the water exceeds 1 km. (1,093 yds.), while in ordinary times, when the volume is only 60 to 80 cub. metres (mean 15,400 gals.), a very small portion only of this surface is occupied by the bed of the torrent, frequently shifted. The utilisation has been effected by diverting the water of the Drac, by means of a submersible weir of slight height, into a large conduit, 4,600 metres (5,030 yds.) long and 3·3 metres (11 ft.) in diameter, laid in the plain formed by the detritus. The difference of level utilised is 37·4 metres (123 ft.) and the volume diverted 17 cub. metres (3,740 gals.) per second, while taking into account the loss of load due to various causes, the useful head becomes reduced to 32 metres (105 ft.), affording 7,200 h.p. The water off-take consists of a fixed weir, a movable weir, and a side-wall, provided with sluices, the water entering a large decantation basin, below which is a canal 600 metres (656 yds.) long, terminating in the chamber whence starts the water under pressure. The conduit for this latter is 4,600 metres (5030 yds.) long, comprising 2,100 metres in armoured cement and the remainder in mild-steel tubes, and 3·3 metres (11 ft.) diameter, while falling 7 cm. per metre (1 in 14·3). The portion in armoured cement, designed to stand a maximum pressure of 20 metres (65½ ft.) water column, is the largest of the kind yet attempted. It consists in an invert of hydraulic-lime concrete, on which rests the tube proper; and the invert is a half-cylinder, of which the section at right angles consists of, for the extrados, a polygon with six irregular sides, and for the intrados a semi-circle. The tube, whose thickness varies from 20 cm. (8 ins.) to 25 cm. (10 ins.), is strengthened by a metal trellis-work, composed of iron rods with meshes of 10 by 11 centimetres (about 4 ins. square). The only point worthy of notice as regards the hoops is that the rods, before being welded, are upset at each end, so that the thickness of metal is greater at the weld than elsewhere, and when subjected to tensile strain the hoops never break at the weld. The mould for executing a tube length of 4 m. (13 ft.) with a single running of the concrete differs from others by its great size and weight, requiring special means for its easy displacement. When the mould was in position and the materials ready in sufficient quantity, every 20 m. (65 ft.) on each side of the trench a light scaffold was put up, consisting of two floors resting on trestles and on the mould itself. On these floors a gang of eight workmen, aided by an equal number of labourers, tempered the concrete, and ran it in turn into the mould until full, this operation lasting about an hour and a quarter. The concrete was allowed to set for half an hour to three quarters, after which the mould was shifted for another length, this work also requiring an hour and a half, so that, with three moulds, about 36 metres (40 yds.) of conduit could be formed daily. As the mass of water moving through the tube was 40,000 cub. metres (8,800,000 gals.), and the speed 2 metres (6½ ft.) per second, three chimneys, two of armoured cement and one of plate-iron, were put up, in order to prevent ram-strokes; and compensating sluice-valves, with a special moderator, prevent—or, at any rate, diminish—overpressures in the conduit. The generating station comprises a service of water under pressure for cooling the oil bath, a railway for sending the transformers to the repair shops, five groups of 1,350 h.p. combined turbine alternators, two groups of 150 h.p. turbine exciters, and a 5 h.p. turbine for filling the hydraulic accumulators that work the servo-motor regulators. The turbines, coupled directly with the alternators, are of centripetal type, with horizontal shaft and cylindrical slide-valve distribution, making 300 revolutions per minute, and employing, when fully loaded, 4 cub. metres (880 gals.) of water per second. The station was started on March 15th last, and has hitherto distributed power very regularly to 57 works, the principal line, 30 km. (18½ mls.) long, consisting of six 7-mm. (⅜-in.) wires, carried by steel posts. The useful effect of the turbines is 0·76, of the alternators 0·94, of the transformers 0·975, of the line 0·94, and of the second transformers and secondary lines 0·9, giving the total efficiency as 58 per cent. of the water-power after a passage of about 50 km. (31 mls.) and a double transformation; and this yield of 58 per cent. affords 4,176 e.h.p., of which 3,300 are already let for long periods. The cost of the electric horse-power at the point of utilisation is 1,200 frs. (£48), and at the turbine shaft about 550 frs. (£22). The capital of the Société Hydro-Electrique de Fure et Morge is 5,000,000 frs. (£200,000); and the rates of subscription are 125 frs. (£5) per horse-power per annum for 12 hours daily, or 150 frs. (£6) ditto for 24 hours daily. —**M. A. Dumas,** *Génie Civil, Vol. xlii, No. 4, 22nd Nov., 1902,* pp. 49–55.

Cost of Air-Compression with Steam and Electricity.

In a paper read before the Canadian Mining Institute, some steam and electric plants tested by the author are fully described. Both kinds were thoroughly modern and representative of their respective types. The result of a 30-days' test showed the saving by electricity

over steam to be 6·4 per cent. Several tables are given showing the work performed, and the cost of operating each plant. —**W. Thompson,** *The Quarry, Nov. 1902,* pp. 698-700.

Explosion-Engines.

THE author considers that alcohol must be regarded as a satisfactory agent for the production of mechanical energy, if sufficient attention is given to the design of carburators and vaporisers, and if suitable precautions are taken to guard against the corrosion of valves by liquids condensed during periods of rest. —**C. Coupan,** *Mémoires Soc. Ing. Civils de France, No. 8, 1902,* pp. 182-85.

Consumption in Gas-Engines.

IN most treatises on gas-engines, the co-efficients used for the purpose of comparing different types of such motors, are for the most part of uncertain and unsatisfactory nature. The author investigates the subject from a purely scientific standpoint, and arrives at the conclusion that further research is necessary for the purpose of making it possible to account for the heat units furnished by combustion. He hopes to throw further light on this subject by some researches which he is about to make in the new laboratories of the Conservatoire des Arts et Métiers.—**J. Deschamps,** *Mémoires Soc. Ing. Civils de France, No. 8, 1902,* pp. 205-17.

The Midland Electric Power Station.

SOUTH Staffordshire forms a first-class field for the enterprise of the Midland Electric Corporation for Power Distribution, Ltd.—formed both for lighting and traction work and for the supply of electric power to the numerous industries of the district. The central generating station is at Ocker Hill, Tipton, practically in the centre of the area of supply, which measures approximately 100 square miles. The central station generates two-phase current at 7000 to 7500 volts, at a frequency of 50 periods. This current is supplied to substations where it is converted in part into continuous current for lighting and traction, and transformed down, in part, for power distribution to works. Sub-stations are at present proposed at Bilston, Tipton, Wednesbury, Willenhall, and Tentenhall. The Bilston sub-station only started working quite recently, and it supplies the whole of the current required by the Wolverhampton District Tramway Company for its 17 miles of line. Messrs. Kincaid, Waller, Manville & Dawson are the engineers responsible for the design and execution of this extensive station.—*Engineering, Nov. 14, 1902,* pp. 629 31.

Surface Condensers.

IN an article on this subject, Mr. C. G. Robbins states the formula given some years ago by Mr. J. M. Whitham for proportioning the cooling surface necessary. The formula is as follows :—

$$\text{Sq. ft. of surface} = \frac{W \times L}{U \times (T - t)}, \text{ in which}$$

W = pounds of steam condensed per hour.
L = latent heat of steam at condenser pressure.
U = heat units transferred per sq. ft. per hour for each degree of difference between steam and water temperatures.
T = temperature of steam at condenser pressure.
t = average temperature of cooling water (half the sum of the entering and leaving temperatures).

While practically correct for ordinary condenser conditions, the writer says that this formula contains assumptions which seriously affect its accuracy over a wide range of temperatures, such as are found in feed-water heaters and other apparatus in which heat is transferred from steam to water through thin metal partitions. The most serious error lies in assuming the average temperature of the water to be its arithmetical mean. This is not strictly correct, because as the final water temperature is always much below that of the steam, it continues to absorb heat as long as it is in the condenser, and its true average temperature is much higher than the assumed average. This decreases the amount of difference, and consequently the heat transmitted per square foot of surface. This fact led to the derivation of a formula by Mr. C. P. Poole, giving the correct average temperature of the water. This formula, as arranged for condensers, is as follows :—

$$\text{Sq. ft. of surface} = \left(\frac{H - h}{F - I} \times \text{hyp. log.} \frac{S - I}{S - F} \times W\right) \div U, \text{ in which}$$

H = heat units in one pound of steam at condenser pressure.
h = heat units above 32° in one pound of condensed steam.
S = temperature of steam at condenser pressure.
F = final temperature of cooling water.
I = initial temperature of cooling water.
U = heat units transferred per hour per sq. ft. per degree of difference, as before.
W = pounds of steam condensed per hour.

The remainder of the article is devoted to an explanation of the manner in which the values of the various factors are to be ascertained, to the working out of numerical examples by the Whitman and Poole formulas.—*Marine Engineering, October, 1902.*

Loss of Heat from Bare Steam Pipes.

PÉCLET'S theory of the loss of heat from a surface maintained at constant temperature gives results in agreement with practical tests of the loss of heat from bare steam pipes. When a metal steam pipe of customary thickness is filled with steam at rest or in motion at ordinary velocities there is a constant escape of heat through the walls of the pipe by conductivity, and on reaching the outer surface a portion is radiated to the surrounding objects and the remainder is carried off by the contact of the surrounding air. Loss of heat by air contact depends on the diameter of the pipe, on its position and on the difference of temperature between its outer surface and the surrounding air. Loss due to radiation depends on the nature of the surface of the pipe, on the difference of temperatures and on the temperatures of the surrounding objects. For the calculation of losses the values of certain co-efficients must be known. These have already been deduced by Péclet from his experiments, but the writer says there are enough reliable experiments on a large scale to make it preferable to deduce the value of K, a number depending on the nature and condition of the pipe surface, directly from them. A table and several diagrams are given in the article, which should be useful to all who require some reliable method of estimating the heat lost by uncovered pipes. The article is followed by a translation of a chapter on the "Emission and Transmission of Heat," from Péclet's celebrated work "Traité de la Chaleur."—**C. P. Paulding,** *Stevens' Inst. Indicator, Oct. 1902,* pp. 385-393.

Superheating.

IN an article on this subject, the author discusses valves, water in the cylinder, and the Schmidt apparatus. Very little is said concerning valves, beyond the remark that a position is to be approved which facilitates the ejection of water entering with the steam, and the perfect draining of the cylinder. Means of overcoming cylinder condensation are then discussed. The steam jacket can, after all, exert but a small effect on steam in the cylinder. The high rotative type of engine is an endeavour to minimise cylinder effects, temperature undulations becoming less in amount, and water produced as mist by the conversion of heat into work being carried off before it has time to settle upon the cylinder walls. Compound engines are another means of combating the evil, all the steam that enters the first cylinder appearing as steam in the second. When the causes of cylinder condensation are understood, it is easy to realise the benefit to be derived from additional heat. The writer then goes on to describe in detail the Schmidt system of superheating, giving illustrations of the superheater and of the superheater and economiser as applied to a Lancashire boiler.—**W. H. Booth,** *Machinery, October, 1902,* pp. 84-86.

Liquid Fuel Combustion.

KNOWLEDGE of the analytical treatment of the combustion of gases and of the vaporisation of oils greatly simplifies the problem of the somewhat complicated series of physical actions involved in oil combustion. The author notes three different classes of systems for the production of oil vapour—(1) The burning of oil in an atmosphere without previous treatment; (2) the burning of vaporised oil in accordance with the Bunsen principle; and (3) the burning of vaporised oil after admixture with air to form an explosive mixture. Early methods of oil burning are described, and then follows an account of some interesting experiments performed by the author, from which he evolved a method for the combustion of any oil in a closed pressure chamber, and without any deposit in the case of residual oils. The paper next illustrates the first application of this method of combustion to a steam boiler and in a reverberatory furnace. — **C. E. Lucke,** *Am.Soc.Mech.E., May, 1902, Trans., Vol. xxiii.*

Rotative Pumping.

THE most remarkable feature in modern engineering is the change from reciprocating to rotative machines such as involve fluid action. The author refers to early attempts at higher heads and pressures by the cumulative action of centrifugal pumps, as applied in England by Prof. Reynolds and on the Continent by Messrs. Sulzer Bros. The Sulzer pump, which belongs to the turbine class, has achieved a wide celebrity, and in one case a triple installation operates against a head of 1,550 ft. with an efficiency of more than 70 per cent. Reference is then made to the Risdon water turbine to explain the principles of the turbine form of pump, and to show the failure of computation to define the curves and other operating features of turbine water-wheels, to which pumps are closely related. As to

the future development of rotative pumps, the author says that in his opinion centrifugal pumps will remain very much as now made, and the turbine that competes with displacement pumps will be a new class and a separate manufacture.—**Jno. Richards,** *Journ. of Assoc. of Eng. Societies, Aug. 1902*, pp. 71–90.

A Method of Calculating Crank Effort.

RECENT discussions regarding the operation of alternating-current machines in parallel involve much abstruse reasoning, and the mathematics on the engine side are those used in finding speed variations, velocity, displacement, and crank-effort curves. As all these curves are derived primarily from the crank-effort curve, it is thought that a short and easy method of producing this curve without using tedious and inaccurate methods will be appreciated. As bare acquaintance with a rule or formula is not so satisfactory as a knowledge of how it is derived, the writer proceeds to explain in detail the evolution of the method proposed for calculations of the kind mentioned.—*Power, Nov. 1902*, p. 6.

TRACTION.

A Comparison of Electric and Steam Traction.

FOR the purpose of obtaining data as to the desirability of applying electric traction in the New York tunnels of the New York Central Railroad, the authors have made a series of trials with trains drawn by steam and electricity respectively, considering especially the acceleration possible in each case. The results of these trials were described in detail in a paper presented at a meeting of the American Institute of Electrical Engineers, and from them we abstract the following. The better utilisation of adherence is demonstrated by the table given below :—

Number of Vehicles.	1	2	3	4	5	6
	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.
Speed attained in 10 secs.						
Electric Traction . . .	22·5	21·7	17·2	14·4	12·6	11·0
Steam ,, . . .	13·9	13·0	12·5	12·0	10·0	9·7
Speed attained in 20 secs.						
Electric Traction . . .	34·0	32·3	29·4	27·9	24·5	21·1
Steam ,, . . .	25·0	21·1	20·2	19·4	18·0	16·2
Speed attained in 30 secs.						
Electric Traction . . .	38·2	36·3	34·2	32·0	30·4	28·1
Steam ,, . . .	31·7	26·1	25·1	24·5	23·2	20·8

It appears that the superiority of the electric motor lies chiefly in the fact that tractive effort is more sustained than in the case of the steam locomotive. The maximum speed of a train traversing a predetermined course in a given time is a development relating to the consumption of energy; but as electric traction exhibits a higher mean speed with a lower maximum speed than is afforded by steam traction, it consequently results in a smaller consumption of energy. The comparison becomes still more striking if, instead of considering the train as a number of carriages hauled by an electric locomotive it is assumed to consist of carriages each fitted with motors, for the dead weight will then be considerably reduced. As a matter of fact the commercial basis for comparison is the cost per passenger-mile, and not the cost per ton-mile. Judged from this standpoint, electric traction shows a considerable advantage, as may be seen by the following table:—

No. of Vehicles.	No. of Passengers.	Watt-Hours per Passenger-Mile.	
		Steam.	Electricity.
6	384	43·63	29·44
5	320	52·00	32·00
4	256	57·12	34·88
3	192	77·44	37·28
2	128	102·40	44·96
1	64	185·60	44·96

—**B. G. Arnold** and **W. B. Potter,** *Proc. Am. Inst. E. E., June, 1902.*

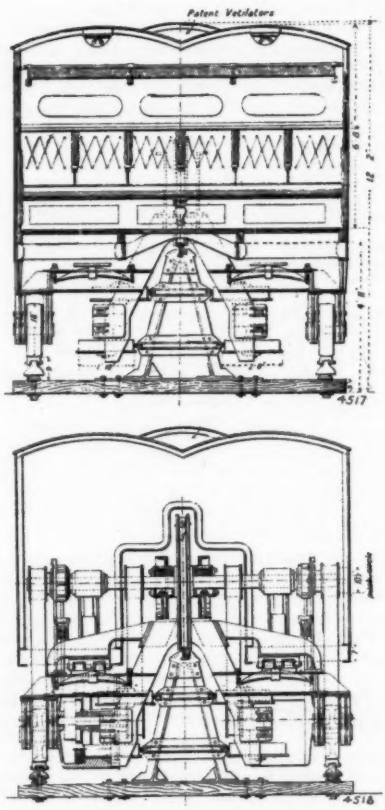
Cylindrical Slide-Valves in Compound Locomotives.

AN account of the results obtained in connection with the use of cylindrical slide-valves on four-cylinder compound locomotives on the system of the Compagnie de l'Est. The author states the reasons which led to the employment of this type of valve, the nature of the arrangements adopted, and the actual results obtained. He says that the indicator diagrams show considerable improvement in engines fitted in the manner described, that the mechanical effect is in every way satisfactory, and that the saving of fuel is proved to be fully ten per cent. This saving is based upon figures furnished during actual running and quite apart from theoretical calcu-

lations. Cylindrical valves are said to be advantageous, chiefly because they make it possible to greatly increase the number of revolutions per minute in compound locomotives, thus facilitating the attainment of higher speeds while reducing the diameter of the driving wheels.—**M. Pelletier,** *Mém. Soc. des Ing. Civils de France, No. 9, 1902,* pp. 376–409.

Manchester and Liverpool Electric Express Railway.

A DESCRIPTIVE illustrated article relating to Mr. F. B. Behr's "monorail," now authorised between Manchester and Liverpool, gives full details of this interesting undertaking. Leaving Manchester viâ Salford, Eccles and Barton, the line passes Irlam and Warrington, and enters Liverpool through Garston and Toxteth, the proposed terminus being between the central station and the Mersey. The total length of the new railway will be 34½ miles, and there will be a double track throughout. Comparatively little of the line will be on the level, the gradients varying from 1 in 25 to 1 in 660. It is intended to establish a ten minute service, and the duration of the journey will be 20 minutes, necessitating a speed of 110 miles an hour. The monorail and the carriages are therefore the items of chief interest in connection with the railway. Full details of the permanent way are described and illustrated in this article; but briefly it may be said that the construction adopted consists of a main rail supported on a succession of trestles, about 4 ft. high, resting on transverse sleepers, and carrying two guide-rails on each side for preventing undue lateral or vertical movement of the carriages. From end to end the line will be protected by an unclimbable fence. It is intended that the carriages shall be run singly, and there will therefore be no "trains" on the line. Three types of car have been designed and approved, to accommodate 72, 50, and 30 passengers respectively. For the initial service the smallest cars, as illustrated, will be employed. The chief feature of the construction will be a central steel frame forming the lower part of the carriage, and built so as to admit of being placed like a saddle over the trestle. Each carriage will have four continuous-current motors, having a normal capacity of 160 h.p., but able to work up to 320 h.p. for short periods. At each side of the carriage four guide-wheels bear against the faces of the guide-rails, the flanged face of each wheel being below the corresponding guide-rail. A certain degree of lateral and vertical movement will be permitted by the use of springs. It is contended by Mr. Behr that this design



MONORAIL, MANCHESTER AND LIVERPOOL. CROSS SECTIONS OF MOTOR CAR.

affords greater safety than that prevailing in the case of an ordinary railway where the carriages are only held on the rails by a flange of about ⅝ in. deep, whereas on the Manchester and Liverpool line the arrangement virtually provides a continuous flange over 3 ft. in depth. For the supply of electricity, two conducting rails will be laid on the sleepers, one on each side of the trestles, and circular brushes will convey current to the motors, which are to be placed in the lowest part of the carriage framework. The generating station at Warrington will furnish current at 15,000 volts on the three-phase alternating system, and there will be five sub-stations, at which current will be transformed and supplied as continuous current at 650 volts. High-speed Westinghouse

brakes will be fitted to the cars, and an automatic system of electrical signalling is contemplated. At the Liverpool terminus the line will be about 60 ft. above the street level, but it is not stated whether the same practice will be followed in Manchester. In working out the engineering details Mr. Behr has had associated with him Mr. R. Elliott-Cooper.—*Tram. and Rail. World, Nov. 13, 1902*, pp. 599-607.

TOOLS AND WORKSHOP PRACTICE.

Comparison of Test Bars.

In continuation of an article in *The Foundry* of September, 1902, the author presents a table relative to test bars of cast-iron which illustrates the convenience of comparing strength by the modulus of rupture, even in the case of such a material as cast-iron, whose qualities are so greatly modified by rates of cooling. The table relates to 24 test bars of different forms and dimensions, and contains data and results under the following heads: Shape and position of cross-section for transverse test, dimensions, length and mass between supports, ratio of mass to cooling surface, moment of inertia of cross-section, factor for the modulus of rupture, breaking load, deflection, calculated rates of contraction. As an illustration of the maximum difference likely to be found in the same bar tested in different directions, the author instances his study on flat white iron bars, made white by chilling from the flat sides only, but chilled totally to the centre. A 4-in. area rectangular bar, broken flatwise by a stress of 16,666 lbs., would, if homogeneous, require 29,631 lbs. to break it edgewise. But if chilled as stated it could easily stand 16,656 lbs. or more flatwise; but edgewise not over 16,000 lbs., as it must then break in detail, because of the direction of the laminated hard structure in relation to the stress. This direction is very apparent to the eye, and in the same way many of the anomalies of cast-iron may be explained upon inspection with the microscope and by the light of metallographical principles. — **Asa W. Whitney,** *The Foundry, Nov. 1902*, pp. 104, 105.

Calculating the Weight of Castings.

In a communication to the American Institute of Mining Engineers, the author describes the following graphic method of estimating the weight of castings made from patterns where the cross section is not a uniform geometrical figure. An accurate drawing of the pattern gives a closer result than a drawing of the casting itself. The example taken by the author is an ordinary cast-iron car wheel. From the full-sized drawing of half the cross section the gross area is taken with the planimeter, and any other areas where there is no metal are deducted. A blue print of the net area A, exclusive of brackets and letters, is then pasted on cardboard and is then balanced on a pin to determine the centre of gravity of the irregular figure. The distance R from the point thus found to the centre line of the wheel axis is measured. Then the weight of the wheel is calculated by the formula: $W = 2\pi R \times A \times W +$ weight of bracket sand letters, minus weight of metal displaced by corelegs. In this rule W = weight of metal per cubic inch. The foregoing method is said to give reliable results for car wheels, and for castings of more regular shape even better results can be expected.—**C. M. Schwerin,** *Am. Machinist, Nov. 15, 1902*, pp. 1538-39.

Slow-advance and Quick-return Motion.

The peculiar movement of the tool-holder in a slotting or shaping machine, in virtue of which the tool advances slowly while making the cut and for the sake of saving time returns quickly while no work is being done, may be produced in several different ways. The method discussed depends upon the varying angular velocity of one elliptical wheel, driven by another which revolves with uniform speed. This method was the subject of a previous article in the *Indicator* of October, 1899, and the present contribution is a mathematical demonstration of the statement in question.—**C. W. MacCord,** *Stevens' Inst. Indicator, Oct. 1902*, pp. 361-9.

VARIOUS.

Thermal Emissivity.

The author gives an account of a new method by which the emission of heat at a surface may be determined. The subject deserves investigation, because all the rules bearing upon it are empirical and suggest considerable conflict of opinion. **J. W. Peck,** *Royal Philosoph. Soc., Glasgow, 1902*, pp. 110-123.

Purification of the Atmosphere by Ozone.

Description of the apparatus patented by Mr. J. Harris for the manufacture of ozone on a commercial scale. The action is as follows: Current is taken from any available source and passed into a small motor-generator, passing thence as a high voltage high frequency current to a special transformer of the Tesla type, where it is transformed to a

very high potential, and passes to metal screens, sparking across from one to the other at a thousand points. These screens are fixed in a closed box, at one end of which is an electric fan, drawing in air which is purified by the formation of ozone under the action of the electric discharge. The apparatus illustrated by the writer is capable of purifying 60,000 cub. ft. of air in ten minutes. —**E. T. Williams,** *Elec. Rev., N.Y.*, Vol. 51, *Nov. 7, 1902*, pp. 77, 78.

The Hesketh Prize.

As an encouragement to members of the London Association of Foremen Engineers and Draughtsmen, this prize was instituted by Mr. Everard Hesketh, M.I.Mech.E., who is connected with the engineering firm of Messrs. J. & E. Hall, of Dartford. Three money prizes of five, three, and two guineas respectively are offered to members of the association for essays on subjects selected from time to time. We have recently received advance copies of five essays contributed on "The various methods of rewarding labour, with their advantages and disadvantages, and of these the best method for obtaining the most efficient results, both in quality and quantity." The essays in question show just appreciation of this important subject, and the prizes have been awarded to the following gentlemen :—Mr. W. Powrie (1), Mr. J. Batey (2), Mr. C. E. Clift (3). The referees are Messrs. Mark H. Robinson, M.Inst.C.E., Frederick H. Harrison, M.I.Mech.E., and Henry Handoll (Past President).

Electrolysis and Corrosion on Condenser Tubes.

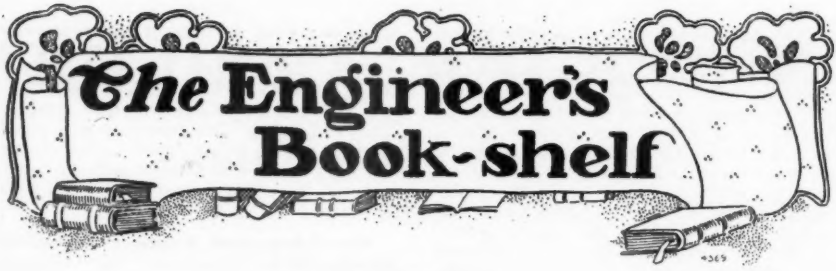
After discussing the nature of electrolysis and noting the manner in which earth-buried piping is generally corroded, the writer suggests that a cure for the corrosion of condenser tubes may be found in the attachment of the positive terminal of a low-voltage generator to one or more large masses of metal buried adjacent to the condenser to be protected, and by soldering the negative terminal in frequent places to the condenser.—**J. F. Hobart,** *Power, Nov. 1902*, pp. 14-16.

Theory of the Gas-Mantle.

A summary of some of the principal theories which have been advanced to account for the luminosity of the gas-mantle is given by the writer. Some of these theories lead to conclusions mutually inconsistent, yet there is no reason why they should not all contain some part of the truth, unless the experiments of Messrs. White, Russell and Traver be considered as conclusive against the idea of the mantle being hotter than the flame. It seems, to the writer, that the most satisfactory explanation is that the high luminosity is due to a combination of the good radiating power, the high temperature, and the selective emissiority of the mantle. All these causes operating together and assisting one another, combine to produce one of the most efficient artificial illuminants that the ingenuity of man has devised.—**M. Solomon,** *Nature, Nov. 27, 1902*, pp. 83, 84.

Oil Systems.

An account of the gravity oiling system adopted in a large power station where the plant included two 1,000-h.p. Allis cross-compound engines and a 4,500-h.p. Westinghouse vertical engine. The storage tank is placed in a pit, so that the top comes 10 ins. above the basement floor, an elevated tank being suspended in the roof, 80 ft. above the engine-room floor. Oil is pumped from the storage tank to the elevated tank, the suction pipe being carried by a float, and return oil from the engines passes through a strainer before entering the tank at the other end. An overflow pipe is provided on the storage oil tank, to prevent water returning with oil from overflowing the tank, and an overflow on the elevated tank permits any excess of oil to pass into the engine return pipe. Amongst other diagrams are two showing methods for raising cylinder oil from the basement to the engine-room floor. In one case, a connnection with the air-pump allowed atmospheric pressure to force the oil up, and in the other the pressure in the city water mains was utilised for the same purpose.—**H. D. Drew,** *Power, Nov. 1902*, pp. 22-25.



Text Book of Electro-Chemistry. By Svante Arrhenius, Professor at the University of Stockholm. Translated by John McCrae, Ph.D. 1902. 9*s.* 6*d.* net. 314 pp. 8vo., with numerous illustrations. (London: Longmans, Green & Co.)

This volume contains the subject-matter of a series of lectures delivered by the author in the University of Stockholm in 1897 with additions made since that date. Dr. McCrae has made his translation from the German edition of the work, and has added a list of references to original investigations on the subject, which will be very useful to the reader. The book gives a purely theoretical treatment of the science of electro-chemistry, so that it cannot be expected to appeal strongly to those who are concerned solely with the practical applications of electricity to the electro-chemical industries. But for the student of theory the case is different. The part which Arrhenius has played in the development of the ionic theory of solutions is so well known that a book containing the expression of his ideas in the English language is sure to receive a large amount of attention from students of chemistry in this country. Some of his views have been the subject of criticism, but all are worthy of close study.

The opening chapter on Fundamental Physical and Chemical Conceptions is somewhat "scrappy"—to use a vulgar but expressive term—and in some respects it is not quite satisfactory. We regret that the author is content to condone, and to some extent to accept, the popular use of the terms "electro-motive force" and "potential difference" as synonymous; as it is, in our opinion, of importance to keep them distinct if confusion is to be avoided. But a worse fault is committed when the author proceeds to say that "the potential corresponds, in a certain sense, to work." The product of potential and the charge moved would denote work done, and of course if unit charge be chosen, the product is the same numerically as the potential, but it ought to be made clear that the potential is only one factor in the product denoting work. This does appear at a later page in the book, but it would have been well to avoid the ambiguity. Chapters III. to VII. are almost purely chemical. In this part the author's discussion of osmotic pressure is especially clear, and contains an account of many interesting experiments. In Chapter VIII. we come to the discussion of the light thrown upon the chemical theories by electrolysis, and from this point onwards we are immersed in the ionisation theory. One chapter is devoted to the calculation of electro-motive forces, and discusses the work of Helmholtz, Kelvin, and Nernst in an interesting manner. In another chapter on "Potential Difference between Two Bodies," the author touches briefly upon contact-electricity, the capillary electrometer and dropping electrodes, and the seat of the E.M.F. in a Daniell element. The final chapter treats of the development of heat by the electric current, and describes briefly various types of electric furnace and the uses to which they are put.

Dr. McCrae has evidently endeavoured to keep as close as possible to the German text in his translation. The English of some passages in the book could have been improved by a freer translation, but his work is so good, taken as a whole, that it would be hypercritical to emphasise these few faults. His list of references appended to the author's text is very complete, and increases the value of the volume. The publishers have done their part of the work in a wholly satisfactory manner; the book is well printed in a good type, and the illustrations are well executed.

A New System of Heavy Goods Transport on Common Roads.—By Bramah Joseph Diplock. London: Longmans, Green & Co., 1902. (6*s.* 6*d.* net.)

This book is written by a patentee for the purpose of describing his inventions and the manner in which it is hoped they may be applied. After an introductory chapter the author mentions his first patent for a traction engine to drive and steer all four wheels, thus doubling the surface contact of the driving wheels. This machine he terms "No. 1 engine," and in the form finally adopted the wheels are driven through differential gears from one motive power, so that each beat of the engine is distributed simultaneously over all four driving wheels, producing the same effect as in a boat when all the oarsmen pull together. The experiments described show that, on roads, area of surface-contact counts for more than weight in obtaining adhesion, and led to the development of what is termed the "Pedrail." In this invention the circumferential contact of the ordinary wheel is replaced by that of separate feet, attached to the periphery of a disc, which is virtually a wheel connected in a special manner with the axle of a vehicle, and the arrangement is such that three of the feet always rest upon the road surface: therefore the action somewhat resembles that of a horse. Each foot is connected by a ball-and-socket ankle-joint to a telescopic spoke, or leg. The legs are drawn inwards by springs, and at the proper time they are pushed outwards, so that the feet can come down upon the road at any required angle to suit the inclination of the surface. A small roller is furnished in connection with each foot, and when three feet are placed upon the ground, the three corresponding rollers are beneath a frame supporting the load, which is levered along over the rollers by the action of the jointed legs. The principle of the Pedrail is described as being an inversion of that adopted in the ordinary railway; for, instead of the wheels running over a rail laid down on the road, the rail moves over wheels laid down on the road. When this novel principle is applied to a road locomotive the engine practically becomes a walking machine, the feet of which accommodate themselves automatically to varying slopes of any reasonable inclination. The engine can walk up or down slopes or even steps, or walk over obstacles 12 ins. high. The tractive force developed is very great, and has been estimated by Prof. Hele-Shaw at 150 to 200 tons on a level road. Similar wheels, if the term may be used, can be applied to the wagons to be drawn by the engine, and the hope of the inventor is that this new system will be largely adopted for the purpose of coping with the demand for a suitable system of heavy goods transport on ordinary roads. After describing the mechanical features of the inventions mentioned, the author goes on to expound a general scheme for the collection and distribution of merchandise, very much upon the basis already adopted by large carrying firms in London. The volume is well worth reading, but the ideals of the author cannot be fully realised until some of the restrictions imposed by existing legislation have been removed.

The "Practical Engineer" Pocket Book, 1903.—Manchester: The Technical Publishing Co., Ltd., 31, Whitworth St. Price 1*s.*; with diary on ruled section paper, 1*s.* 6*d.*

It is with pleasure we acknowledge the receipt of, and welcome the fifteenth annual issue of this handy little compendium, which we may truthfully say has been one of our most constant companions since it first saw the light of day a decade and a-half back, Its sphere of usefulness has not diminished, some recent additions having been made with a view to further increasing its efficiency. No matter what the position of the engineer may be, he can at any time turn over to the Pocket Book with a pretty sure idea of finding what he wants in its most concise and lucid form.

The Steam Turbine. By Robert M. Neilson, A.M.I.Mech.E. (London: Longmans, Green & Co., 1902.)

As the President of the Engineering Congress at Glasgow remarked, the steam turbine is one of the most interesting examples of mechanical engineering since the time of Watt. For this reason, and also because the efficiency and economy of the turbine are now established, it is very desirable that the public should have before them a book setting forth the theory of this machine, and the various forms in which it is now manufactured. The work to which this notice refers is well worth perusal.

Water-Tube Boilers. By Leslie S. Robertson, M.Inst.C.E., M.I.Mech.E. (London: John Murray.)

Much has been said on the subject of water-tube boilers during the last year or so. Their use is strongly advocated by some engineers, and as strongly deprecated by others, both for marine and for land purposes. Our readers are more particularly interested in the latter, and to those who are not already familiar with the merits and the demerits of water-tube boilers we recommend Mr. Robertson's treatise as a reliable and admirably written guide. The book contains a large number of sectional drawings, and appears to illustrate and describe every known type of water-tube boiler.